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ORIGINAL ARTICLE

Assessment of side branch patency using a jailed semi-inflated balloon technique with coronary bifurcation lesions

Koroner bifurkasyon lezyonlarında 'jailed semi-inflated balloon' tekniği ile yan dal açıklığının değerlendirilmesi

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ABSTRACT

Objective: Many interventional cardiologists are concerned about the risk of side branch (SB) loss during main vessel (MV) stenting in complex bifurcation lesions. Therefore, novel techniques are required to reduce the risk of SB occlusion. The jailed semi-inflated balloon technique (JSBT) is one of these techniques. This article is a description of clinical experience with SB patency assessment using the JSBT.

Methods: A total of 64 patients with 82 distinct coronary bifurcation lesions underwent percutaneous coronary intervention (PCI) via JSBT at this institution. In the majority of patients, the SB balloon was inflated with a greater pressure (4.8±2.0 atm) than in the standard JSBT. Procedural and immediate clinical outcomes were reviewed via baseline and post-procedural quantitative coronary angiography analysis.

Results: The majority of the patients had acute coronary syndrome (60.9%) and almost one-third of the patients were Medina class 1.1.1. (32.8%). A jailed-balloon or wire was not entrapped during any PCI. SB ostial dissection was seen in only 2 patients. The minimal lumen diameter was improved in the MV and SB following PCI. There were no adverse cardiac events during in-hospital stay or at 1-month follow-up.

Conclusion: JSBT provides maximum SB protection with bifurcation lesions and requires less time than a complex technique. There was no significant SB occlusion risk even though the SB balloon was inflated with a slightly higher pressure. The immediate clinical outcomes and procedural success of this study may encourage interventional cardiologists to use this technique safely with reliable preservation of SB patency.

ÖZET

Amaç: Birçok girişimsel kardiyolog kompleks bifurkasyon lezyonlarında ana damara stent yerleştirme sırasında yan dalın tıkanma riski nedeniyle kaygılıdırlar. Bu yüzden yan dalın tıkanma riskini azaltmak için yeni teknikler gereklidir. 'Jailed semi-inflated balloon' (JSB) tekniği bunun için geliştirilmiş tekniklerden biridir. Bu yazıda JSB tekniği ile yan dal açıklığını değerlendirdiğimiz klinik deneyimimizi açıklamaktayız.

Yöntemler: Kliniğimizde toplam 82 koroner bifurkasyon lezyonu bulunan ve JSB tekniği ile perkütan koroner girişim (PKG) uygulanan 64 hasta alındı. Hastaların çoğunluğunda yan dal balonu JSB tekniğinden farklı olarak daha yüksek basınçla şişirildi (4.8±2.0 atm). İşlemsel ve erken klinik sonuçlar, başlangıç ve işlem sonrası kantitatif koroner anjiyografi analizi ile değerlendirildi.

Bulgular: Hastaların çoğunluğu akut koroner sendrom olup (%60.9) yaklaşık üçte biri Medina sınıf 1.1.1 idi (%32.8). Jailed balonu yada teli hiçbir PKG işlemi sırasında sıkışmadı. Yan dal ağzı diseksiyonu yalnızca iki hastada meydana geldi. PKG sonrası minimal lümen çapının ana dalda ve yan dalda düzeldiği görüldü. Hastanede yatış sırasında ve birinci ay kontrollerinde ise hiçbir ciddi kardiyak istenmeyen olay görülmedi.

Sonuç: Jailed semi-inflated balloon tekniği bifurkasyon lezyonlarında maksimum yan dal koruması sağlamakla beraber aynı zamanda kompleks bir tekniğe göre daha kısa sürmektedir. Yan dal balonu daha fazla basınçla şişirilmesine rağmen anlamlı yan dal tıkanması görülmedi. Erken klinik sonuçlar ve işlemsel başarı, girişimsel kardiyologları yan dal akımını korumadaki güvenilirliği ile bu tekniği rahatlıkla kullanma konusunda cesaretlendirebilir.

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Coronary bifurcation lesions occur in 8% to 15% of percutaneous coronary interventions (PCIs) in daily practice.[1] PCI of these lesions is associated with a higher rate of adverse cardiac events and poorer long-term outcomes than non-bifurcation lesions.[2–4]

The key point in the treatment of bifurcation lesions is the determination of the most suitable strategy for each lesion. Some lesions require double stenting.[5] In randomized clinical trials of coronary bifurcation stenting, better outcomes were reported using a simple (provisional) strategy rather than complex (culotte, crush, and T-stenting) techniques with drug-eluting stents. The provisional strategy appears to be associated with lower long-term mortality.[6–8] However, many interventional cardiologists still consider the provisional technique unfavorable for complex bifurcation lesions due to the threat of side branch (SB) loss during main vessel (MV) stenting.[9] Carina and plaque shift, ostial conformational and bifurcation angle changes, protrusion of the stent struts or dissection into the SB can be listed as reasons for SB occlusion.[10] Restoration of the flow after MV stenting may prove difficult in the majority of cases. Therefore, novel techniques and different methods are required to decrease the risk of SB occlusion. A modification of the provisional stenting strategy called the jailed-balloon technique (JBT) was intended to increase SB patency. In this technique, the uninflated balloon, which remains jailed under the stent struts, serves to reduce carina or plaque shifts due to its SB ostium spatial occupation.[11,12] However, it cannot completely prevent SB occlusion.[13] A new technique for better SB protection called the jailed semi-inflated balloon technique (JSBT) seems to be more effective. In this technique, the SB balloon is inflated at a low pressure (3 atm).[14] This study is a description of clinical experience with JSBT that provided more reliable patency of the SB ostium by using a slightly higher pressure (4.8±2.0 atm).

METHODS

Study population

This was a single-center observational prospective study conducted between April and October 2017. The study population consisted of 64 patients (mean age: 59.5±12.2 years). A total of 82 distinct coronary bifurcation lesions from these 64 patients were analyzed. Eighteen patients with cardiogenic shock or who had cardiopulmonary resuscitation, with contraindications for antiplatelet agents, with lesions with proximal tortuosity, heavily calcified lesions, or protected left main disease were excluded. The patients included in the study were fully informed prior to the study and provided written approval for the PCI procedure. The ethics committee approved the study protocol. The study complied with the Declaration of Helsinki.

Abbreviations:

ACS	*Acute coronary syndrome*
CABG	*Coronary artery bypass surgery*
CAD	*Coronary artery disease*
CK-MB	*Creatine kinase MB*
JBT	*Jailed-balloon technique*
JSBT	*Jailed semi-inflated balloon technique*
LAD	*Left anterior descending artery*
LMCA	*Left main coronary artery*
MACE	*Major adverse cardiac event*
MI	*Myocardial infarction*
MV	*Main vessel*
PCI	*Percutaneous coronary intervention*
POT	*Proximal optimization technique*
QCA	*Quantitative coronary angiography*
SB	*Side branch*
TIMI	*Thrombolysis in myocardial infarction*

All of the patients underwent a detailed cardiovascular examination. Baseline characteristics were recorded. The patients were questioned concerning hypertension, hyperlipidemia, diabetes mellitus, and non-cardiac diseases, their current smoking status, previous myocardial infarction, PCI or coronary artery bypass surgery (CABG), family history of coronary artery disease (CAD), and medication use.

Vessel size in the MV had to be ≥2.5 mm and ≥2.25 mm in the SB according to visual evaluation. The Medina classification was used for each coronary bifurcation lesion.[15] Before deciding on PCI, intracoronary nitroglycerin is routinely administered, if the blood pressure is appropriate. True bifurcation lesions were defined as stenosis of >50% in both the MV and the ostium of the SB.[16]

All of the patients received aspirin (300 mg) and a loading dose of clopidogrel (300–600 mg), ticagrelor (180 mg) or prasugrel (60 mg) prior to or at the time of procedure. During the PCI, an intra-arterial bolus of unfractionated heparin was given under activated clotting time guidance.[17]

All of the patients were observed for complications related to the procedure in the coronary intensive care unit and cardiology wards following the PCI. The patients were discharged and followed up with outpatient visits for up to 1 month. All of the patients were to receive aspirin 81 to 325 mg daily indefinitely and clopidogrel (75 mg daily), prasugrel (10 mg daily), or ticagrelor (180 mg daily) for a duration of at least 1 year.

Procedure

A 6–F or 7-F coronary guiding catheter was used via a transradial or transfemoral approach for the procedure. Both branches of the bifurcation were accessed with standard 0.014 inch coronary guidewires, typically using a short or long 180–300 cm wire in the MV and SB. Predilatation of the MV or SB was performed with a semi-compliant balloon if necessary. A second generation drug-eluting stent was then advanced over the lesion in the MV. A semi-compliant balloon that was angiographically sized to approximate the SB vessel diameter (generally 1.5–2.5 mm and of adequate length) was advanced into the SB beyond the ostium. The proximal markers of the SB balloon and MV stent balloon were aligned. However, in our study, for most patients the SB balloon was inflated with a higher pressure (4.8±2.0 atm) than in the JSBT. The MV stent balloon was inflated with nominal pressure. During inflation of the MV stent balloon, the proximal part of the jailed SB balloon (behind the MV stent) was compressed and contrast was squeezed, overinflating the distal part of the balloon at the SB ostium. The jailed semi-inflated balloon prevented carina or plaque shift due to full occupation of the SB ostium. In addition, due to deflation of the proximal part of the SB balloon, barotrauma did not occur at the proximal part of the MV stent, since both the MV stent balloon and the SB balloon were deflated together. After the SB balloon and wire were removed, the MV stent balloon was removed. Lastly, for optimization, the proximal optimization technique (POT) was implemented with a short, non-compliant balloon for the MV stent.

After the PCI, the patients were monitored. Cardiac troponin I and creatine kinase MB (CK-MB) and were measured for all of the patients at least twice 6 to 8 hours post intervention.

Quantitative coronary angiography

Quantitative coronary angiography (QCA) analysis was performed by a single investigator unaware of the patients' clinical outcomes using offline analysis of the computer-based edge-detection coronary angiography analysis system (CGR DXC system; GE Healthcare, Inc. Chicago, IL, USA, with software; Digital Imaging and Communications in Medicine-compliant). Each bifurcation lesion was obtained in 3 segments: the proximal and distal main vessels, and the side branch. For quantitative analysis, at least 2 orthogonal projections were obtained. The angiographic frames were selected in a view good opening. For the calibration reference, the contrast-filled catheters used ranged in diameter from 6-F to 7-F. Reference vessel diameter, minimal lumen diameter, and diameter stenosis were measured in 3 segments according to the algorithm of the dedicated software.[18] Twenty patients were selected randomly to evaluate intra- and interobserver variability.

Procedural and clinical outcomes

The procedural outcomes for each index PCI were independently reviewed by an author who was not an operator in the case. SB occlusion was defined as thrombolysis in myocardial infarction (TIMI) flow grade <3 immediately after MV stenting. Angiographic success was described as successful implantation of a stent and final residual stenosis of ≤30% without MV and SB flow impairment. Each angiogram was reviewed for any procedural complications, including SB loss (temporary or permanent), dissection (proximal and distal stent edge or SB ostium), and jailed-balloon rupture or entrapment.

Periprocedural MI was defined in non-acute coronary syndrome (ACS) patients as at least 1 CK-MB elevation of more than 3 times the upper reference limit, and in ACS patients as a ≥20% increase in elevation following stable or declining CK-MB levels, according to the recommendations of the Academic Research Consortium.[19]

A major adverse cardiac event (MACE) was defined as a composite of cardiac death, myocardial infarction (MI) and target lesion revascularization. MACE was evaluated during in-hospital stays and at 1-month follow-up.

Statistical analysis

All of the statistical calculations were performed using SPSS Statistics for Windows, Version 17.0 (SPSS, Inc., Chicago, IL, USA). Continuous variables were expressed as the mean and SD or the median (interquartile range), as appropriate, and categorical variables were presented as counts and percentages. Pre- and postprocedural QCA analyses were compared using the non-parametric Wilcoxon sign-rank test. A p-value of <0.05 was considered significant.

RESULTS

Baseline clinical characteristics are shown in Table 1. The mean age of the patients was 59.5±12.2 years and 37 (57.8%) of the patients were male with a high prevalence of risk factors for CAD. Sixteen patients had a previous history of PCI and 4 patients had a previous history of CABG. The majority of the cases (60.9%) were admitted to the emergency service with ACS, and all of the patients were discharged following PCI with at least dual antiplatelet therapy. The bifurcation lesion and stenting characteristics are presented in Table 2. The majority of lesions affected the left anterior descending and a diagonal branch. Lesion localization was the distal left main coronary artery (LMCA) in 9 (14%), the left anterior descending artery (LAD)-diagonal 1 branch level in 27 (42.1%), the LAD-diagonal 2 in 16 (25%), the circumflex artery-obtuse marginal branch level in 9 (14%), and

Table 1. Baseline clinical characteristics (n=64)

	n	%
Age (years), Mean±SD	59.5±12.2	
Gender		
Male	37	57.8
Female	27	42.2
Hypertension	44	68.8
Diabetes mellitus	26	40.6
Hypercholesterolemia	35	54.7
Smoking	31	48.4
Family history of CAD	18	28.1
Prior PCI	16	25
Prior by-pass surgery	4	6.2
PCI indication (n=64)		
Stable angina	25	39.1
Non-STEMI	21	32.8
STEMI	18	28.1
Number of diseased vessels (n=64)		
One vessel	21	32.8
Two vessels	33	51.6
Three vessels	10	15.6

CAD: Coronary artery disease; PCI: Percutaneous coronary intervention; STEMI: ST-segment elevation myocardial infarction.

Table 2. Bifurcation lesion and stenting characteristics (n=64)

	n	%	Mean±SD
Lesion location			
Distal LMCA	9		
LAD-D1	27		
LAD-D2	16		
Circumflex artery-obtuse margin	9		
RCA-posterior descending-PL	3		
Bifurcation characteristic			
Medina 1.1.1	21		
Medina 1.1.0	15		
Medina 1.0.1	10		
Medina 0.1.1	12		
Medina 0.1.0	4		
Medina 1.0.0	2		
Bifurcation angle			
<70°	48		
70°–90°	12		
>90°	4		
Main vessel pretreatment TIMI flow			
0–1	9		
2	13		
3	42		
Side branch pretreatment TIMI flow			
0–1	6		
2	14		
3	44		
Transradial approach	8	12.5	
Glycoprotein IIb/IIIa inhibitors	7	10.9	
Predilatation			
Main vessel	39		
Side branch	7		
Main vessel stent size			
Diameter (mm)			2.8±0.3
Length (mm)			20.6±5.9
Side branch balloon size			
Diameter (mm)			1.9±0.4
Length (mm)			13.6±2.5
Mean number of stents			1.2±0.5
Procedural time (minutes)			15.0±3.7
Main vessel stent type			
Sirolimus eluting stent	22		
Zotarolimus eluting stent	4		
Everolimus eluting stent	25		
Biolimus eluting stent	13		

D: Diagonal branch; LAD: Left anterior descending artery; LMCA: Left main coronary artery; PL: Posterolateral branch; RCA: Right coronary artery; TIMI: Thrombolysis in myocardial infarction; SD: Standard deviation.

Table 3. Procedural and clinical outcomes

Procedural success, %	100
Peri-procedural myocardial infarction, %	0
Major adverse cardiac event, %	0
Side branch loss	
Temporary, %	0
Permanent, %	0
Side branch TIMI flow after main vessel stenting	
0–2	0
3	64
Dissection	
Proximal stent edge	3
Non-STEMI	0
STEMI	2
Stable angina	1
Distal stent edge	0
Side branch ostium	2
Non-STEMI	1
STEMI	1
Stable angina	0
Plaque shift	3
Non-STEMI	0
STEMI	1
Stable angina	2
Carinal shift	2
Non-STEMI	1
STEMI	0
Stable angina	1
Side branch stenting	4
Non-STEMI	1
STEMI	2
Stable angina	1
Final kissing-balloon inflation	5
Non-STEMI	1
STEMI	2
Stable angina	2
Jailed-balloon or wire entrapment	0

STEMI: ST elevation myocardial infarction; TIMI: Thrombolysis in myocardial infarction.

the right coronary artery posterior descending artery-posterolateral artery level in 3 patients (4.6%). The transfemoral approach was used in the majority of patients (n=56; 87.5%). Twenty-one of the patients (32.8%) had a Medina 1.1.1 lesion and 43 (67.1%) patients had a true bifurcation lesion (Medina 1.1.1., Medina 1.0.1., or Medina 0.1.1.).

Forty-eight (75%) patients had a Y-type (<70°) bifurcation angle. Pretreatment TIMI 3 flow in the MV and SB was observed in 42 (65.6%) and 44 (68.7%) of the patients, respectively. Predilatation of the MV and SB was performed for 39 (60.9%) and 7 (10.9%) lesions, respectively. The mean number of stents placed was 1.2±0.5.

In Table 3, procedural and clinical outcomes are displayed. There was no peri-procedural occurrence of MI and there was no MACE during in-hospital stay or at the 1-month follow-up. Clinical subgroup analysis was also included in the table. All of the patients had a TIMI 3 flow in both the MV and SB after stenting. Two examples are illustrated in Figures 1 and 2. Figure 1 shows a patient who was admitted to the emergency clinic with an ST-segment elevation MI. Figure 1(a) shows the bifurcation lesion in the circumflex artery-obtuse level on caudal view with Medina 0.1.0; (b) After positioning of the MV stent and SB balloon, the SB balloon was inflated to low pressure; (c) The MV stent balloon was inflated with nominal pressure, jailing the SB wire and semi-inflated balloon; (d) The MV stent balloon and SB balloon were deflated together and the SB balloon was removed; (e) POT was performed, and the final angiographic result is shown in Figure 1 (f). Figure 2 illustrates an elective PCI procedure related to the LMCA. Figure 2(a) shows the bifurcation lesion in the distal LM coronary artery on caudal view with Medina 1.1.1; (b) The MV stent balloon was inflated with nominal pressure, jailing the SB wire and semi-inflated balloon in the circumflex artery; (c) POT was performed, and the final angiographic result is shown in Figure 2 (d). Only 2 patients had carina shift and 3 patients had plaque shift. One of the patients who had plaque shift was treated using a provisional inverted mini-crush technique. The second of the 3 patients was treated with the T and minimal protrusion technique. For the last, the final kissing balloon was sufficient without stenting. SB ostial dissection developed in only 2 patients after MV stenting and we performed a provisional inverted mini-crush technique for both. In 1 case, the SB balloon was inflated at 3 atm and the other was inflated at 6 atm. In the first patient, the size of the SB balloon was 1.5 mm and for the other it was 2.5 mm. However, those patients had high-grade stenosis

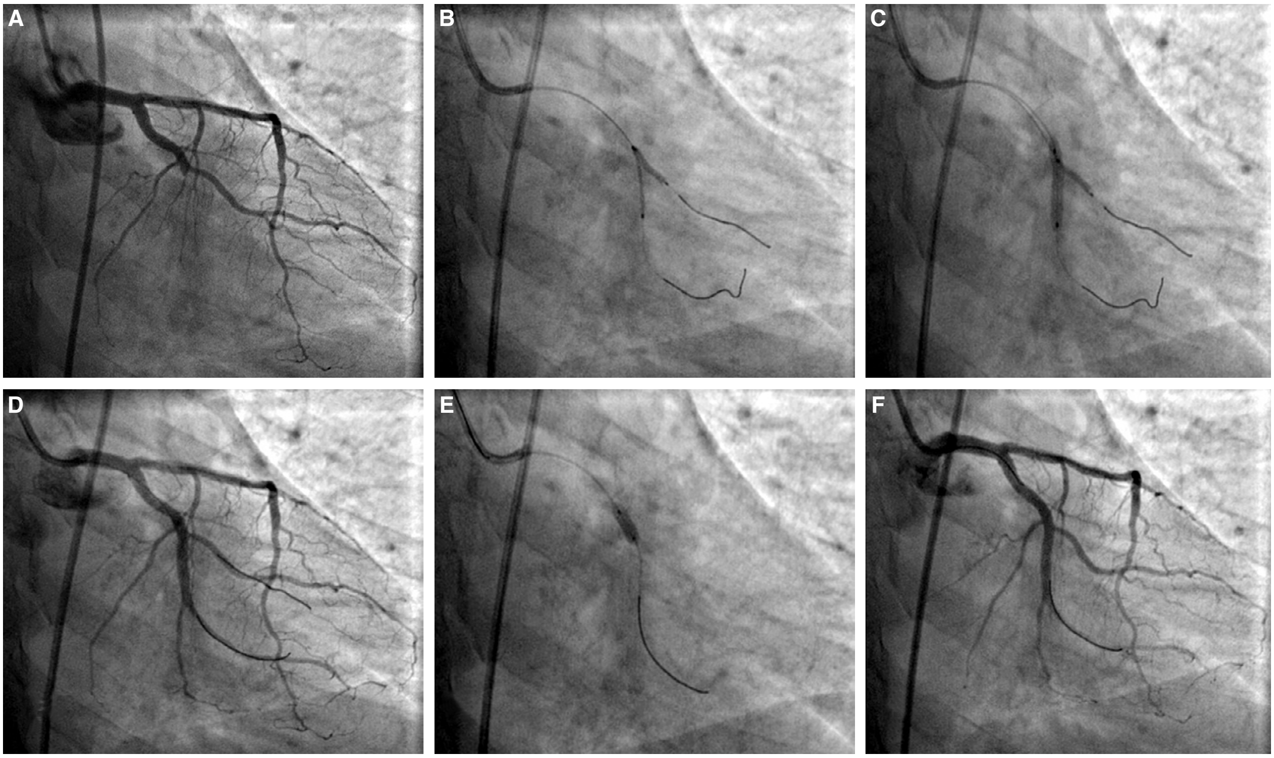

Figure 1. **(A)** Appearance of bifurcation lesion in the circumflex artery-obtuse level on caudal view with Medina 0.1.0; **(B)** After positioning of the MV stent and SB balloon, the SB balloon was inflated to low pressure; **(C)** MV stent balloon was inflated with nominal pressure, jailing the SB wire and semi-inflated balloon; **(D)** Appearance of the lesion after the MV stent balloon and SB balloon were deflated together and the SB balloon was removed; **(E)** Proximal optimization technique was performed with a short non-compliant balloon; and **(F)** Final angiographic result.

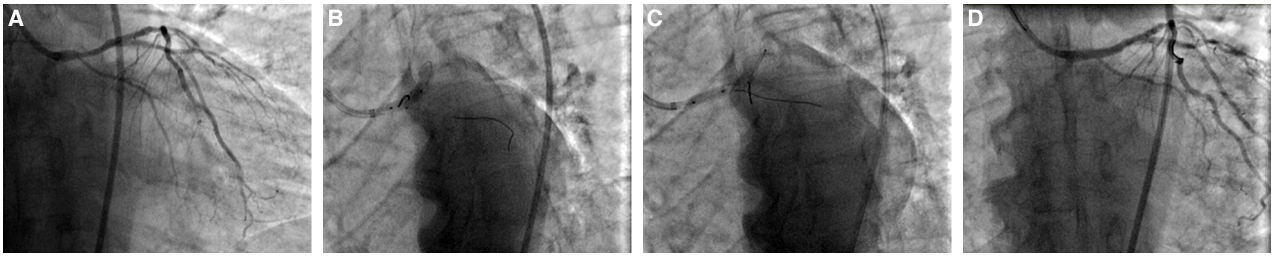

Figure 2. **(A)** Appearance of bifurcation lesion in the distal left main coronary artery on caudal view with Medina 1.1.1; **(B)** MV stent balloon was inflated with nominal pressure, jailing the SB wire and semi-inflated balloon in the circumflex artery; **(C)** Proximal optimization technique was performed with a short non-compliant balloon; and **(D)** Final angiographic result.

at the SB ostium. Both of the patients who developed SB ostial dissection were ACS patients. We added an additional stent because of proximal stent edge dissection in 3 patients. The jailed balloon or wire was not entrapped or ruptured in any case. None had flow compromise in the SB and significant procedural success was achieved in the current study.

QCA analysis for the MV and SB is shown in Table 4. The minimum lumen diameter improved in the MV and SB following PCI.

DISCUSSION

The JSBT for PCI of complex coronary bifurcation lesions had a high immediate procedural success rate in patients treated with a provisional approach. In addition, there was no significant SB occlusion risk, despite the slightly higher inflation of the SB balloon. The jailed SB balloon was successfully removed in all cases. This technique still looks successful, without MACE or any SB loss, despite the higher SB balloon

Table 4. Pre and postprocedure quantitative coronary angiography analysis for the main vessel and side branch

	Preprecedure	Postprocedure	*p*
Proximal main vessel			
Reference vessel diameter (mm)	3.11 (2.84–3.44)	3.14 (2.82–3.42)	0.9
Minimum lumen diameter (mm)	0.8 (0.5–1.2)	3.05 (2.76–3.28)	<0.001
Diameter stenosis, %	76.95 (60.95–83.9)	2.45 (1.8–3.8)	<0.001
Distal main vessel			
Reference vessel diameter (mm)	3.0 (2.79–3.32)	3.02 (2.77–3.26)	0.8
Minimum lumen diameter (mm)	0.85 (0.65–1.1)	2.88 (2.71–3.14)	<0.001
Diameter stenosis, %	73.4 (61.75–81.6)	2.9 (2.2–3.8)	<0.001
Side branch			
Reference vessel diameter (mm)	2.31 (2.24–2.6)	2.32 (2.2–2.62)	0.9
Minimum lumen diameter (mm)	0.87 (0.7–1.44)	1.36 (1.14–1.6)	<0.001
Diameter stenosis, %	65.4 (52.37–74.82)	42.3 (26.87–55.2)	<0.001

Quantitative coronary angiography analysis was compared using the non-parametric Wilcoxon sign-rank test. Median and interquartile range (IQR, 25th–75th percentile) of reference vessel diameter, minimum lumen diameter and diameter stenosis (%).

inflation. Thus, the results of our study are encouraging and interventional cardiologists may elect to use this technique with reliable preservation of SB patency.

This technique was successfully used in patients in both the emergency and elective clinical setting. The majority of the study population presented with ACS and bifurcation lesions. The complication rates seem to be higher in patients with ACS, as expected by clinical and lesional physiology, when compared with roughly stable patients. For example, 2 patients who developed SB osteal dissection in the study were ACS patients. However, in all of the patients, a TIMI 3 flow was provided both in the MV and in the SB. There was also no MACE, as in stable angina patients. These results indicated that the method is also applicable to patients with ACS.

In addition, although JSBT is generally considered to be an acceptable method when there is no significant stenosis in the SB ostium, 67% of the patients in our study had a true bifurcation lesion. Thus, we have also shown that this technique can be successfully applied in patients with SB ostial lesions. However, regardless of the lesion in the SB ostium, tortuosity or heavily calcified lesions of the SB are major limitations for this method. This method has not been used in such cases.

PCI of coronary bifurcation lesions is associated with a lower rate of procedural success, poor long-term outcomes, and a higher rate of adverse cardiac events when compared with non-bifurcation lesions, including periprocedural MI, target lesion revascularization, and stent thrombosis.[4]

Numerous stenting techniques (culotte, crush, and T-stenting) have been proposed to improve the procedural and clinical outcomes of PCI of coronary bifurcation lesions. The key point in the treatment of bifurcation lesions is determination of the most suitable strategy for each lesion.

A meta-analysis of provisional versus complex strategies demonstrated an increased incidence of MI in the complex strategy cases.[20] The graft bifurcation anatomy during stenting limits the success of many of these techniques. Many interventional cardiologists still consider the provisional technique inferior for complex bifurcation lesions because of the risk of SB loss.[21] However, the 5-year analysis of the Nordic Bifurcation Study and the British Bifurcation Coronary Study suggest that a provisional single-stent approach appears to be associated with lower long-term mortality than a systematic dual stenting technique.[22] In addition, the provisional approach reduces procedural time, radiation, and contrast administration, compared with the elective dual stenting technique.[6,7] But if a SB occlusion happens during the provisional technique, adverse events may be expected.[23] The major predictors of SB occlusion are smaller SB diameter, sharper bifurcation angles, ostial or near-ostial SB disease, and especially plaque shift during

MV stenting.[24] The JBT was intended to increase SB patency. In this technique, the uninflated balloon, which remains jailed under the stent struts, allows for treatment of any plaque shift that occurs during stenting of the MV without losing access to the SB.[11] Depta et al.[12] retrospectively analyzed a recordable series of bifurcation lesions in patients who underwent a provisional method with or without JBT. They demonstrated that the SB loss rate was significantly lower in the JBT group. However, this technique is not adequate to prevent SB occlusion.[13] Especially after postdilatation, if the stent balloon is inflated with higher pressure, the carina may shift into the SB and/or distal edge dissection may occur. Ultimately, Çaylı et al.[14] proposed the new technique of JSBT for better SB protection in a study of 137 patients, which seems superior to previous techniques. The SB balloon is inflated to a low pressure (3 atm) and the SB balloon fully occupies the SB ostium. The procedure is finalized with POT to ensure appropriate apposition of the stent struts to the vessel wall. In their study, intravascular ultrasound was used to demonstrate the effectiveness in some cases. The procedural success rate was 100% without any SB loss. Ostial SB dissection developed in 4 patients. Three of 4 patients were treated with SB stenting. We thought that greater SB balloon inflation would provide more SB patency. In our study, only 3 patients had plaque shift and only 2 patients had SB ostial dissection after the MV stenting in which the provisional inverted mini-crush technique was used for management. The results of our study were similar to the study of Çaylı et al. In addition, there was no significant plaque or carina shift or ostial SB dissection observed, despite the higher SB balloon inflation. The jailed SB balloon and wire were successfully removed in all patients without damage.

Study limitations

JSBT was not compared with other techniques, such as JBT. Additional larger, randomized studies are needed, as well as longer follow-up, to compare this technique with other complex (culotte, crush, and T-stenting) techniques. The small size of our population sample is another limitation of this study. Furthermore, the use of different types of drug eluting stents, although they were all new-generation stents, is also considered a limitation of our study, given the different mechanical properties, such as cell design and strut thickness. Also, we did not use any imaging methods (intravascular ultrasound or optical coherence tomography) in our study. However, we performed QCA analysis for the MV and the SB.

Conclusion

The JSBT provides maximum SB protection in cases of bifurcation lesions and requires less time than a complex technique. There was no significant SB occlusion risk, even though the SB balloon was inflated with a slightly higher pressure. The immediate clinical outcomes and procedural success of this study may encourage interventional cardiologists to use this technique safely with reliable preservation of SB patency.

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