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Provisional Stenting Techniques Using A Novel Modified Jailed Balloon

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Abstract

Coronary bifurcation lesions are frequently found; account for one-fifth of all Percutaneous Coronary Interventions (PCI), and are considered as complex cases to treat. The provisional stenting strategy is thought of as the stenting of choice for most coronary bifurcation lesions. Still, it has a risk of side branch (SB) occlusion after the main vessel (MV) stenting. Several strategies have been proposed to overcome this challenge. Jailed balloon technique (JBT), first proposed by Burzotta et al. in 2010 was a more recent modification of jailed wire technique (JWT) to further decrease the risk for SB occlusion during crossover stenting in bifurcation lesion. Since then, certain modifications had been tested to the conventional jailed balloon technique to maximize SB protection during the provisional stenting strategy. We tried to make a mini case series of 6 patients with application of jailed ballon technique with some modifications in bifurcation lesion with provisional stenting strategy and evaluate its efficacy and safety, with quite satisfying results. Our novel JBT technique had some different characteristics from previous JBT techniques and aimed at simplifying the procedure while preserving side branch during crossover stenting.

Keywords: *Percutaneous Coronary Intervention, Bifurcation Lesion, Provisional Stenting, Jailed Balloon Technique*

1. BACKGROUND

Bifurcation lesions are commonly encountered in coronary angiography and account for 15-20% of all percutaneous coronary interventions (PCIs). Coronary bifurcation stenting is considered complex and challenging and associated with a higher rate of adverse cardiac events, higher risk for procedural complications, and poorer long-term outcomes than non-bifurcation lesions. Provisional stenting is the default strategy for bifurcation intervention, but it is associated with the risk of side branch (SB) closure after main vessel (MV) stent implantation. Protecting the SB to keep it open is one of the main principles when performing bifurcation lesion intervention. Dedicated bifurcation techniques, such as jailed wire technique (JWT) and jailed balloon technique (JBT), have been proposed to help SB protection.

The most commonly employed strategy to protect a significant SB during provisional stenting is to jail a coronary wire in the SB. However, rewiring and salvaging the impaired SB were not always successful and can be challenging. JBT, first proposed by Burzotta et al., might provide better protection to side branch occlusion during provisional stenting. Since then, various modifications had been applied to the original technique, aimed at even better protection of the side branch. Largely, jailed balloon technique is divided into 2 groups, Conventional Jailed Balloon Technique (C-JBT), and Modified Jailed Balloon Technique (M-JBT), with some different characteristics that distinguished one technique from the other. The differences between C-JBT and M-JBT included the initial position of the jailed balloon and the timing of jailed balloon inflation. The differences and steps of C-JBT and M-JBT was illustrated in Figures 7-9. In this article, we described our clinical experience by doing a mini case series of slightly modified provisional stenting techniques using a jailed balloon that allowed the preservation of side branch patency. [1-7]

2. CASE PRESENTATION

We made a mini case series of patients who were undergoing provisional stenting PCI with jailed balloon technique which has some modifications, thus a bit different to either C-JBT and M-JBT. We added some tweaks to the previous technique to simplify the procedure and optimize the result. The differences between our modification and previous techniques were described in detail in discussion. the clinical characteristics of the patients and the procedure was listed in table 1.

Table 1. Clinical and procderual characteristics from the mini case series.

No.	Patient, age	Risk factors	Diagnosis	Bifurcation vessel	Medina class.	Stent & balloon size	SB compromised
1.	Mr. Af, 59yo	DM, HT, ex-smoker	Acute inferior STEMI	RCA/ RV branch	1-1-1	3.0x38mm 2.0x15mm (12 atm)	No
2.	Mrs. Ag, 76 yo	Dyslipidemia, HT	NSTEMI	LCX/OM1	1-1-1	3.0x18mm 2.0x15mm (12 atm)	No
3.	Mr. Mu, 61yo	HT, smoker	NSTEMI	LAD/D2	1-1-1	3.0x38mm 2.5x15mm (12 atm)	No
4.	Mr. No, 55yo	-	Acute anterior STEMI	LAD/D1	0-1-1	3.0x24mm 2.0x15mm (12 atm)	No
5.	Mr. Ha, 61 yo	HT, ex-smoker	NSTEMI	LAD/D1	0-1-1	2.75x29mm 2.0x15mm (12 atm)	No
6.	Mrs. Ka, 66yo	HT	UAP	LAD/D1	1-0-1	3.0x38mm 2.0x15mm (12 atm)	No

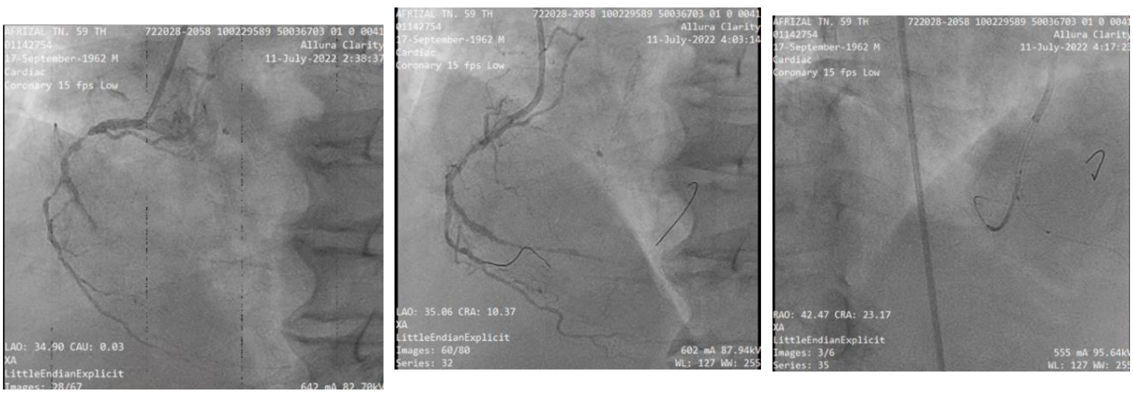


Figure 1. Illustration of case 1. (1) angiogram revealed diffuse stenoses from proximal to distal RCA with total occlusion in distal, accompanied by tight stenoses in the RV branch, making it Medina 1-1-1 bifurcation. (2) wiring to both vessels was completed using workhorse wire. (3) after enough lesion preparation, we placed stent 3.0x38mm in MV and balloon 2.0x15mm in ostium RV branch, and doing implantation MV stent sequenced by JB inflation in nominal pressure (4) JB was slightly pulled to the MV and re-inflation of the JB was done while MV balloon stent was still positioned in the stent. (5) JB was completely pulled, and the stent was fully expanded. (6) final result showed good TIMI flow in both MV and SB with no SB compromise.

Figure 2. Pictures of case 2. (1) stenoses 70-80% at proximal-distal LCX with critical stenoses at OM. (2) angioplasty with LCX stenting and jailed balloon at OM was done. (3) good flow at LCX with no OM loss.

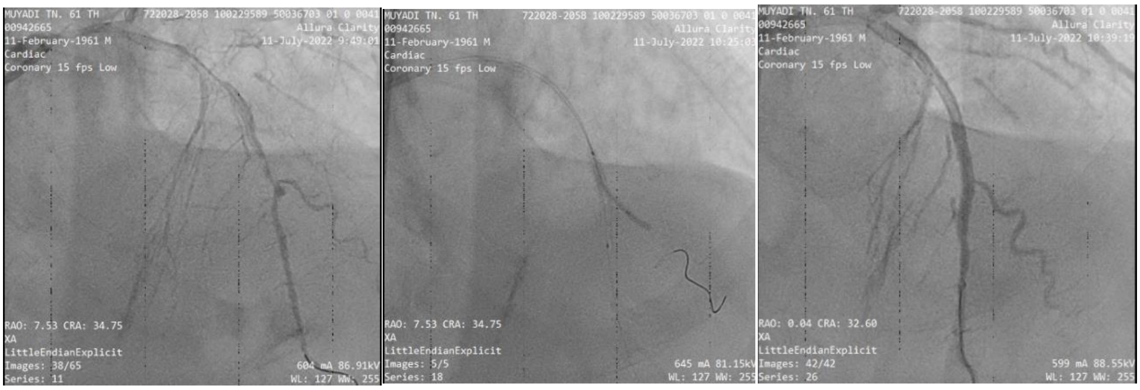


Figure 3. Pictures of case 3. (1) angiogram showed 70-80% stenoses at proximal-distal LAD accompanied by 80% at ostial diagonal. (2) PCI was performed with LAD stenting and jailed balloon at diagonal. (3) final result showed good flow at both LAD and diagonal

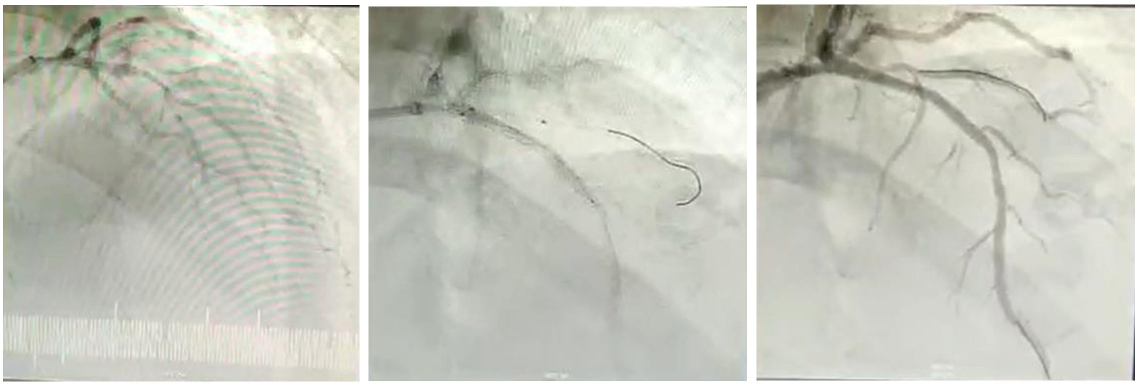


Figure 4. Pictures of case 4. (1) angiogram revealed 70-80% stenoses at mid-LAD and tight stenoses at the ostial diagonal. (2) jailed balloon was placed at the ostial diagonal during LAD stenting. (3) good TIMI flow at both LAD and diagonal as the final result.

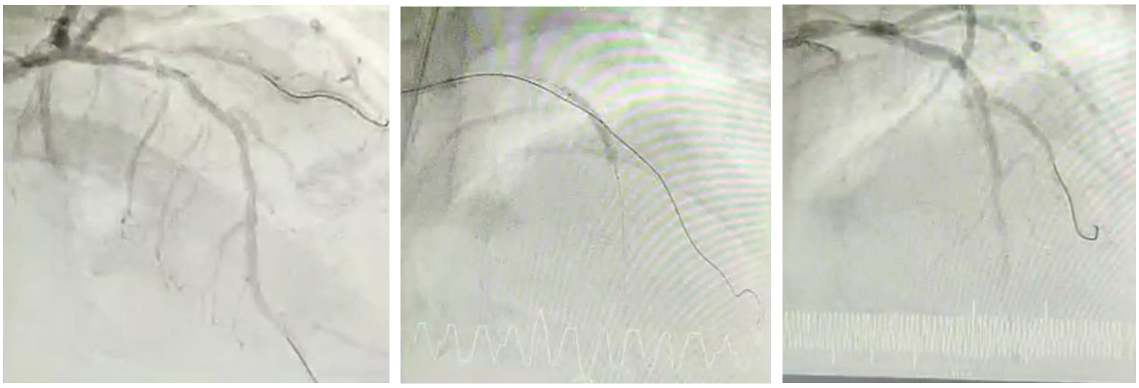
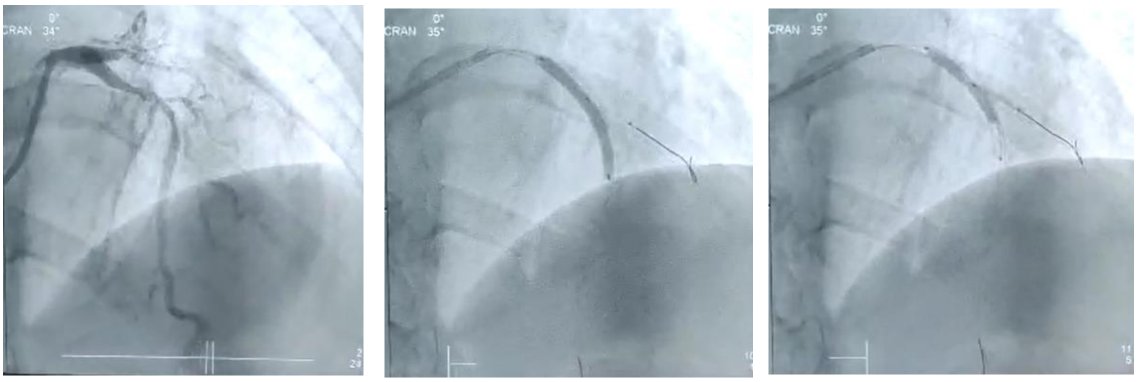


Figure 5. Pictures of case 5. (1) significant stenoses at proximal to mid-LAD and ostial diagonal. (2) jailed balloon was positioned and inflated at low pressure after being pulled halfway to the MV to decrease resistance and risk of stent deformation. (3) final result showed good flow at LAD with no diagonal compromise.



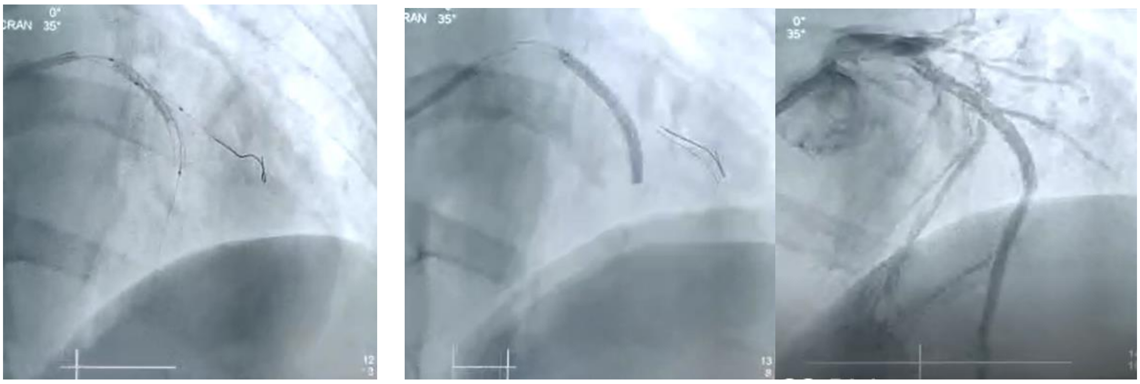


Figure 6. Case 6 illustration. A 66 years-old female with unstable angina. (1) angiogram showed 70-80% stenoses at proximal LAD and 80-90% at ostial diagonal with 1-0-1 Medina classification. (2) after completing lesion preparation, LAD stenting with a 3.0x38mm stent was performed with a 2.0x15mm balloon and was jailed and adjusted at ostium diagonal uninflated. (3) jailed balloon was then inflated sequentially after LAD stenting. (4) jailed balloon was pulled halfway to MV and re-inflated with MV balloon stent stayed in position. (5) jailed balloon was removed entirely, and the stent was fully expanded. (6) The final result showed TIMI 3 flow without compromise at MV and SB.

3. DISCUSSION

Coronary bifurcation stenting remained complex and challenging and associated with more incredible technical difficulty, a lower rate of procedural success, and a higher rate of adverse cardiovascular outcomes, including periprocedural myocardial infarction (MI), target lesion revascularization (TLR), and stent thrombosis. [4, 8] Provisional stenting is the default strategy for bifurcation intervention, but it is associated with the risk of SB closure after MV stent implantation. Side branch (SB) occlusion may be a disaster during coronary bifurcation intervention and could lead to serious adverse clinical events. SB occlusion can result in vessel closure and ischemia, with clinically significant myocardial infarction (MI) and even death, depending on the size of the SB (and the myocardial territory supplied by it). SB occlusion after MV stenting occurs in 7.4%–8.4% of bifurcation lesions and brings a severe complication during angioplasty. SB occlusion increases 6-fold the risk of stent thrombosis (ST) and cardiac death by four times. The risk of cardiac death remains higher even after blood flow can be re-established. [5, 9-12]

Several mechanisms can be responsible for SB occlusion during MV stenting, including critical stenosis or SB occlusion develops, SB rewiring is attempted to try to save the SB flow. But, the effort to rewire SB and restore SB flow after MV stenting can be difficult. In addition, prolonged flow impairment in SB may cause peri-procedural myocardial infarction. [13-15]Protecting the SB to keep it open is one of the main principles when performing bifurcation lesion intervention. Several strategies are proposed to reduce the loss of SB during the provisional stenting strategy. The placement of a second wire in the SB during MV stenting ("jailed wire technique, JWT") is known to reduce the risk of SB occlusion and was performed in an estimated one-third of bifurcation lesion cases with significant stenoses on both MV and SB. However, efforts to rewire and salvage the impaired SB were not always successful and can be stressful experiences for the operator. The jailed wire also could be trapped after MV stenting, making it hard to pull from the side branch or fractured during withdrawal. Thus this technique was not completely safe. [1, 13, 16] A modification of the provisional stenting strategy called the jailed-balloon technique (JBT) is designed to increase SB patency. JBT is considered more effective in preserving SB patency without increasing procedural complication rates. CIT-RESOLVE trial showed that JBT had a lower rate of myocardial infarction, target lesion revascularization, and MACE composite of all-cause death than the JWT group. [1, 10]

The jailed balloon technique was first proposed by Burzotta et al. They speculated that a jailed balloon in the SB during MV plaque shift, carina shift, bifurcation angle changes, spasm, or dissection into the SB. If tenting might provide a more helpful tool to reduce plaque/carina shift than jailed wire due to its higher occupation of the SB ostium. They successfully performed this technique in 20 patients with complex bifurcated lesions undergoing stent implantation. Since then, various modifications have been applied to the original jailed balloon technique to improve further side branch patency, such as jailed semi-inflated balloon technique by Ermis and Cayli et al. and modified jailed balloon by Saito et al.[5, 11, 13, 17]

Overall, JBT was classified into two groups; the original technique by Burzotta et al., which has some slight modifications, was termed the conventional jailed balloon technique (C-JBT). In comparison, the modification proposed by Saito et al. was called the modified jailed balloon technique (M-JBT). The C-JBT had some characteristics that distinguished it from M-JBT. First, the position of the SB balloon overlapped the MV stent completely across the bifurcation point, and the proximal marker of the MB stent and JB were closely aligned. Second, JB is inflated with low pressure (≤3 atm) only when SB flow is compromised after MB stenting. Suppose SB flow is not impaired after MV stent implantation. In that case, the jailed balloon may be removed uninflated, with the difficulty of removing the jailed balloon, that is, in both bench tests and the first clinical experience, comparable to that encountered during jailed wire removal. [1, 5, 16] The steps of C-JBT are explained in Figures 7 and 8.

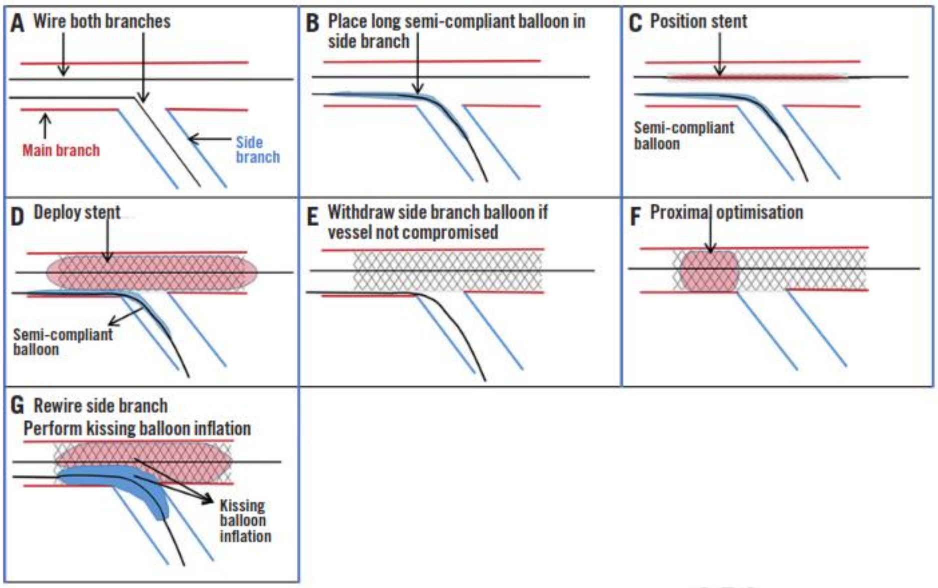


Figure 7. Steps of conventional jailed balloon technique without side branch compromise [16]

Some slight modification was proposed by Ermis et al. and Cayli et al. In their studies, the JB position was similar regarding the stent. However, before MV stent deployment, the JB was always semi-inflated in low pressure. This technique was called jailed semi-inflated balloon technique (JSBT). (13, 17)In C-JBT, more excellent occupancy of the SB ostium is thought to ensure better side branch patency. Resistance during balloon withdrawal after MV stenting was deemed not more than that encountered during jailed wire removal. Moreover, in case of more resistance, while pulling back the jailed balloon, low-pressure inflation was recommended rather than the application of force. No major MV stent malapposition was observed after applying low-pressure inflation during intravascular imaging post-stenting. (5, 16)

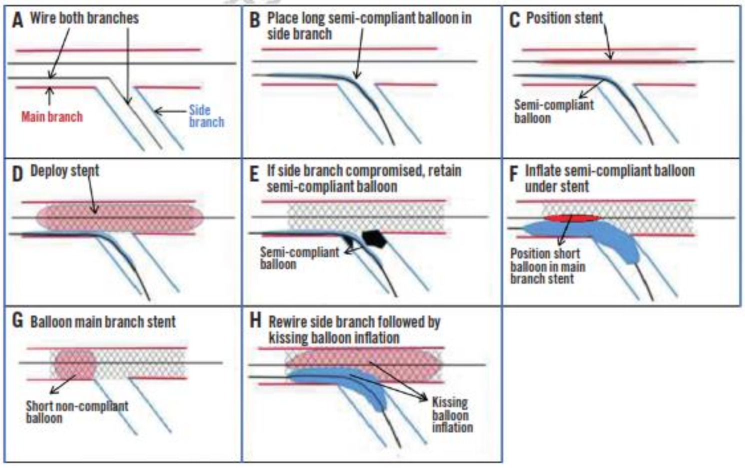


Figure 8. Steps of conventional jailed balloon technique with side branch compromise. (16)

M-JBT (modified jailed balloon) was first proposed by Saito et al. and characterized by three points. First, the proximal end of JB is carefully positioned and adjusted so that only its proximal end attaches to the side of the MV stent. Second, the size of JB used is uniformly decided to be half of the MB stent size and not more than the SB diameter. Third, both JB and MB stent is always dilated simultaneously with around 12 atm (nominal pressure). These measures were invented to prevent plaque or carina shifting during MB stent implantation. This technique was proposed to overcome the MB stent deformation in the proximal part of bifurcation induced by SB inflation. This was evidenced by the significantly less eccentricity index in M-JBT than in C-JBT. (1, 11) The steps of the modified jailed balloon are explained in Figure 9.

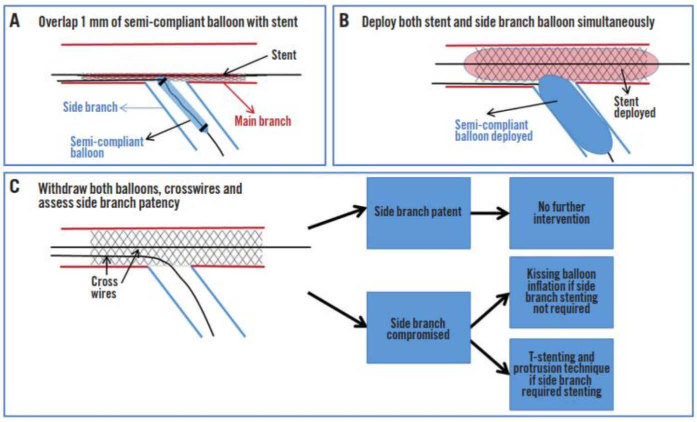


Figure 9. Steps of modified jailed balloon technique. (16)

One disadvantage of the C-JBT is that it becomes quite a complex procedure when an SB becomes occluded, although SB closure was reported in only 1 out of 19 cases. In such cases, the SB balloon should be deployed, but for it to be deployed, another balloon had to be ready and positioned in the MV to immediately correct any stent distortion that results after SB balloon deployment. Any residual distortion would make rewiring challenging. While trying to correct distortion, vascular wall injury and edge dissections are possible to happen. (5, 16)

We tried to make some modifications to the JBT aimed at simplifying the procedure while still being able to preserve the side branch that was deemed important. The steps of our jailed balloon technique were as listed. First, after stenting the main vessel while placing a balloon in the osteal of the side branch, we ensured the SB had been adequately occupied by inflating the JB sequentially after deploying the stent. It was done in order to secure SB patency. Second, we re-inflated the balloon after pulling it halfway to the MV while keeping the stent balloon in position to ensure the balloon in SB could be pulled safely with minimal resistance without causing stent deformation. Third, we fully expanded the stent using the stent balloon after removing the jailed balloon. Fourth, we performed the Proximal Optimization Technique (POT) to correct stent deformation, make rewiring the side branch easier, and prevent abluminal rewiring if such action was needed. One of the main disadvantages of C-JBT is the distortion in the proximal part of the stent caused by the kissing balloon routinely performed in C-JBT. This deformation was reflected from the optical domain frequency imaging (OFDI) studied by Saito et al. They found that the eccentricity index in C-JBT was significantly larger than its counterpart in the proximal part of MV stent, but not in the distal part, as was shown in figure 10. This deformation can cause malapposition of the stent strut to the arterial wall and make it challenging to recross a guidewire and/or balloon into SB. This deformity should be corrected to facilitate easy rewiring into SB through the MV stent strut; thus, final KBD and/or stenting in SB, if needed, can be performed. We tried to fix the deformity that might happen by fully expanding the stent balloon after JB inflation was removed, followed by doing POT to ensure the stent distortion was adequately corrected. (7, 11)

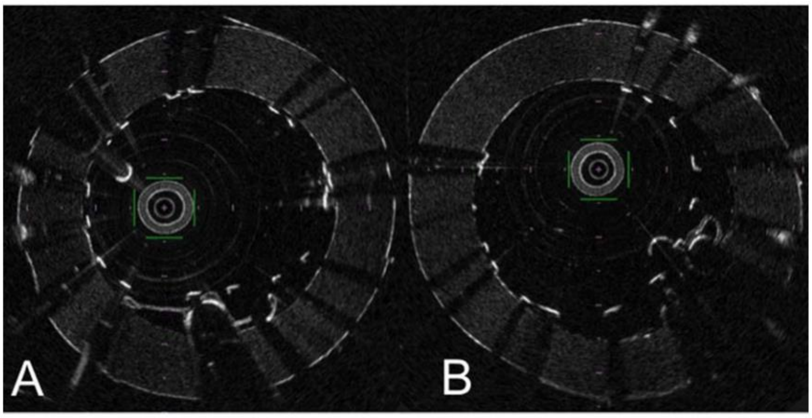


Figure 10. Images of OFDI in in vitro study. The eccentricity index in C-JBT (1.248, label A) was typically larger compared to M-JBT, whose eccentricity index is 1.025 (label B)(11)

So far, in our limited experience, we have found some advantages while performing our jailed balloon technique. First, we do not need to rewire both MV and SB.

It significantly simplifies the procedure without leaving any distortion in the MV stent. Second, we made sure the stent was not malapposed with good expansion and that distortion in the proximal part of the MV stent was corrected. It was done by fully expanding the balloon stent after removing the jailed balloon, followed by performing POT. The steps of our JBT are pictured in figure 11.The results from our limited experience were quite good. From 6 patients undergoing provisional stenting strategy with our version of JBT, we experienced no SB loss. We also did not find any difficulty in pulling jailed balloon and wire back after procedure. It should be noted that most patients were in acute coronary syndrome, which had more probability of SB compromised during provisional stenting. The plan was to follow up with all the patients undergoing this technique to evaluate the rate of target vessel failure and target vessel revascularization in short, medium, and long-term follow-up. We also intend to do intravascular imaging to evaluate the apposition of the stent implanted. (

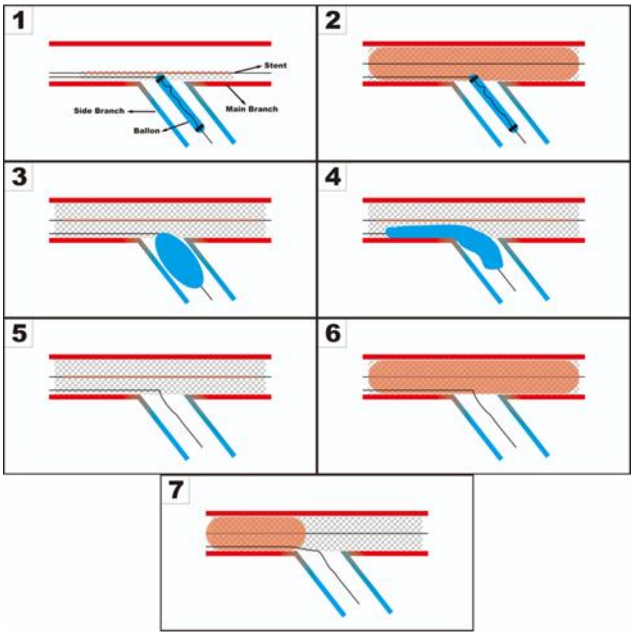


Figure 11. Stepwise of our modified jailed balloon technique. (1) stent was positioned in MV while JB was adjusted in osteal SB. (2) stent was inflated at nominal pressure. (3) JB was inflated sequentially after the MV stent balloon was deflated. (4) JB was pulled halfway to the MV and inflated in low pressure while keeping the MV stent balloon in the previous position. (5) JB was pulled completely, MV stent balloon stayed in position. (6) MV stent balloon was re-inflated in full expansion at the operator's discretion. (7) POT was performed with a short NC balloon to correct residual proximal stent distortion.

4. CONCLUSION

Bifurcation lesions represent a challenge to the interventional cardiologist. They account for up to one-fifth of all lesions encountered in clinical practice, and side branch compromise is a major complication while doing provisional stenting to tackle these bifurcation lesions. When performing bifurcation stenting, determining SB eligibility and its closure risk is very important. JBT has higher success than JWT in keeping SB preserved during provisional stenting in bifurcation lesions and may be an optimal option for protecting the SB, especially lower-size SB. There have been a lot of modified procedures ever proposed over JBT, and our limited experience while doing the JBT with our slight modification produced quite good results. No side branch loss happened during procedure, with no other complications.

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