A Case of Novel Two-Stent technique for Complex Coronary Bifurcation Intervention: The "Carina-Crush" Technique

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Abstract

Most coronary bifurcation lesions could be successfully treated by provisional stenting strategy rather than complex two-stent strategy, as recommended by current guidelines. However, upfront two-stent strategy is suggested in some specific conditions, but it is still inconclusive which technique is the best in terms of clinical outcome. In order to fully cover the whole lesion and reduce the metallic strut overlap, we propose a novel "carina-crush" two-stent technique in this case study. Under optical coherence tomography guidance, this left anterior descending-diagonal branch bifurcation lesion was successfully treated.

Keywords: bifurcation, two-stent technique, optical coherence tomography, drug-eluting stent

Introduction

Bifurcation lesions account for 15-20% of all percutaneous coronary interventions (PCIs),[1] and are considered a complex situation associated with relatively higher risk of stent thrombosis and restenosis after intervention,[2] even in the current era of drug-eluting stents (DES). The optimal intervention strategy varies for each bifurcation lesion depending on the angle, size discrepancy, importance of the side branch (SB) and operator's preference. In general, stenting the main vessel only followed by provisional balloon angioplasty with or without SB stenting is recommended by current guidelines as the class I indication.[3] However, in some specific complex bifurcation lesions, such as large SB with long significant ostial narrowing or anticipated difficulty in accessing an important SB after main vessel stenting, upfront two-stent strategy significantly reduces clinical events when compared to provisional stenting.[4] When a two-stent strategy is necessary, which technique should be preferred is under debate, especially in non-left main (LM) bifurcation. We present a case of left anterior descending artery (LAD)-diagonal branch (DB) bifurcation lesion treated by novel "carina-crush" two stent technique.

Case report

A 64-year-old Taiwanese gentleman, ex-

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smoker, presented to our outpatient clinic with a history of typical effort-related angina for months, which radiated to the bilateral upper limbs and was soon relieved by resting. He also had hypertension and received regular medication treatment from a local clinic. No other systemic disease was reported such as diabetes mellitus, dyslipidemia or chronic kidney disease. He was admitted to our hospital in October 2020 for invasive coronary angiography (CAG) without prior stress test. Electrocardiography revealed normal sinus rhythm without ST-T changes and echocardiography disclosed preserved left ventricular ejection fraction without wall motion abnormality or significant valvular lesion. Trans-radial CAG showed a significant bifurcation lesion involving proximal to middle LAD and a major DB (Figure 1A and 1B). Both left circumflex artery and right coronary artery had insignificant lesions only.

A 7 French extra-backup 4.0 guiding catheter (Medtronic, Minneapolis, Minnesota) was deployed for this intervention and two Fielder FC guide wires (Asahi Intecc, Nagoya, Japan) were used to wire both the LAD and the DB. After wiring, both the LAD and the DB lesions were pre-dilated with a 2.5*12 mm balloon (Figures 1C and 1D) followed by optical coherence tomography (OCT, Abbott Vascular, Santa Clara, California) and pullbacks from both branches. The OCT pullback from the LAD showed a long lesion about 35 mm in length with dissected plaque due to ballooning (Figure 1E). The distal and proximal references in diameter were around 3.0 mm and 3.75 mm, respectively. The DB pullback revealed significant ostial lesion about 7 mm in length and the distal reference was 2.75 mm in diameter (Figure 1F).

The proximal edge of a 2.75*12 mm DES (Xience Sierra, Abbott Vascular, Santa Clara, California) was landed at the proximal branching point (the takeoff point of the DB at the lateral side) of the DB intentionally with a 3.0*15 mm non-compliance (NC) balloon parked at the LAD beyond the bifurcation (Figure 2A and 2B). After DB stenting, the stent was post-dilated by the stent

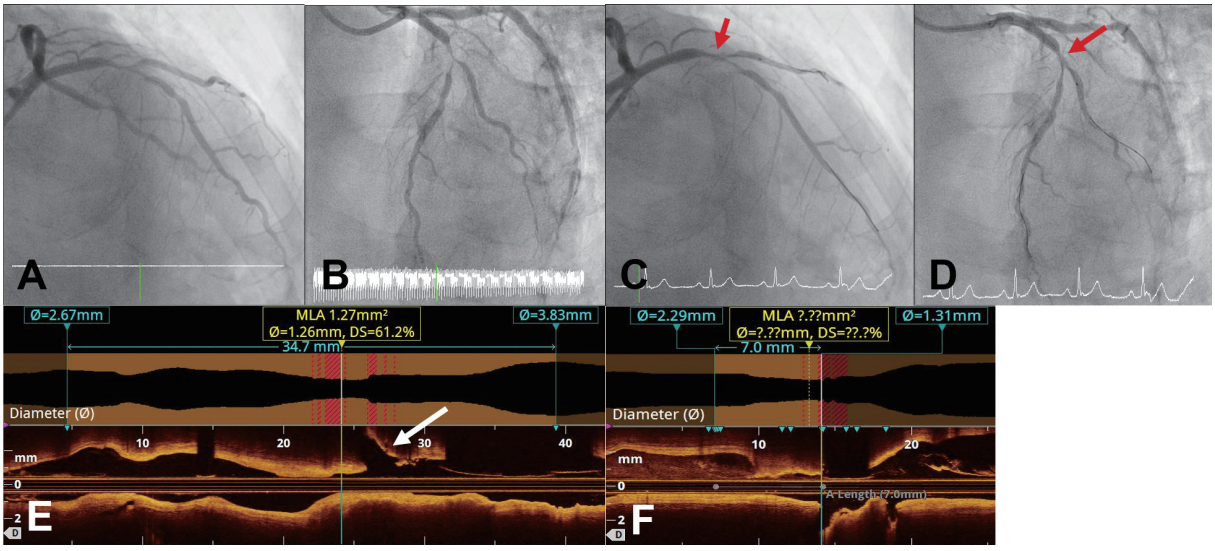

Figure 1. Angiographic and OCT findings before stenting. (A) Baseline RAO cranial view of the LAD-DB bifurcation lesion. (B) Baseline LAO cranial view of the bifurcation lesion. (C, D) After predilation, the arrows indicate the proximal branching point of the DB. (E) OCT pullback from the distal LAD, revealing a 34.7 mm long diffuse lesion. The arrow indicates the proximal branching point of the target DB. (F) OCT pullback from DB. The lesion is 7 mm in length and the orifice is involved. OCT, optical coherence tomography; RAO, right anterior oblique; LAD, left anterior descending; DB, diagonal branch; LAO, left anterior oblique.

balloon up to 16 bars after minimal withdrawal and then the stent was crushed by the 3.0 NC balloon. Another OCT pullback from the distal LAD was performed at this stage, which disclosed precisely the proximal landing of the DB stent, while the minimally protruding strut at the carina side was deflected proximally to the long axis of the LAD by the crush, which did not fully cover the DB orifice (Figure 2E). Another 3.0*38 mm Xience Sierra DES (Abbott Vascular) was implanted smoothly at the long LAD lesion across the stented DB, followed by proximal optimization technique (POT) using a 3.75 mm NC balloon just proximal to the LAD-DB carina. After POT, the stented DB was rewired and followed by sequential 2.75 mm and 3.0 mm NC balloon post-dilatation for the DB and LAD, respectively. After snuggle kissing balloon technique for the LAD and DB with the corresponding NC balloon, the procedure was finished by re-POT with the 3.75 mm NC balloon (Figure 2C and 2D). Both final OCT pullbacks from the LAD and DB showed adequate stent expansion and apposition without edge injury or geographic missing. The DB orifice was opened wide with full stent coverage and a very short metallic neo-carina (Figure 2F).

Discussion

In the current case, we demonstrated a novel two-stent technique by precisely landing the proximal edge of an SB stent at the proximal branching point such that the SB stent strut only protruded minimally at the carina side. The length of the protrusion was decided by the bifurcation angle and should be longer in shallow angles and vanish in vertical bifurcations such as T-stenting.

Most bifurcation lesions should be treated by the provisional approach rather than systemic two-stent approach, in terms of clinical outcomes.[5] In a pooled analysis, compared to the provisional strategy, the 5-year mortality was higher among

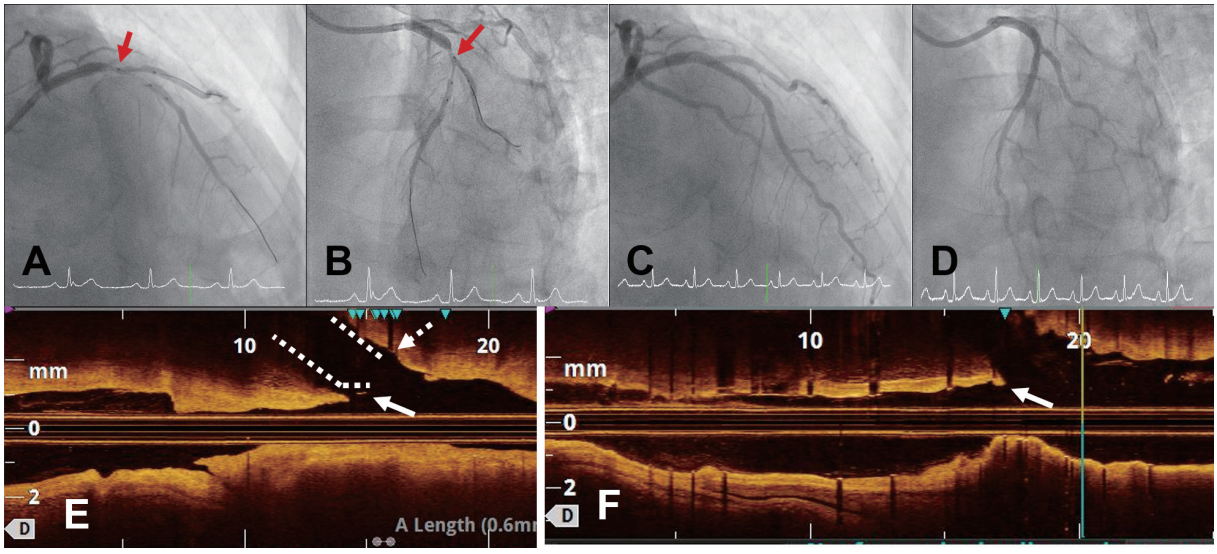

Figure 2. Angiographic and OCT findings after stenting. (A, B) DB stent positioning before LAD stenting. The arrow indicates the proximal edge of the stent landed at the proximal branching point. (C, D) Final angiographic results after stenting. (E) OCT pullback from LAD after the DB stent was crushed, but before LAD stenting. The dashed line indicates the DB stent strut. The dashed arrow indicates how the proximal edge of the DB stent was landed precisely at the proximal branching point. The solid arrow indicates the minimally protruding strut at the carina side, which was deflected to the long axis of the LAD. (F) Final OCT pullback from DB shows the whole lesion fully covered by the stent, and the arrow indicates the metallic neo-carina. OCT, optical coherence tomography; DB, diagonal branch; LAD, left anterior descending.

patients treated by two-stent strategy with greater procedural- and fluoroscopy times and contrast volume.[6] In the EBC TWO (European Bifurcation Coronary TWO) randomized trial, there was no difference between a provisional T-stenting strategy and a systemic 2-stent culotte strategy in a composite endpoint of death, myocardial infarction and target vessel revascularization when treating complex coronary bifurcation lesions with large, stenosed SB.[7]

However, upfront two-stent strategy should be considered in some specific bifurcation lesions. In the DEFINITION study, complex bifurcation lesions had higher rates of 1-year major adverse cardiac events (MACE) than simple lesions, but the 2-stent technique for complex lesions elicited a lower rate of one-year cardiac death and in-hospital MACE than provisional stenting.[4] Recently, the concept was validated in another LM bifurcation study.[8] The three most widely used 2-stent techniques are culotte, the crush family such as classical crush, mini-crush, nano-crush, double kissing (DK) crush and T-stent, and T and protrusion (TAP). Several studies have compared these strategies but the conclusions remain under debate. In the Bifurcations Bad Krozingen (BBK) II randomized trial, culotte stenting was associated with a significantly lower incidence of restenosis at 9-months when compared to TAP technique.[9] In the Nordic Stent Technique study, both crush and culotte stenting were associated with similar and excellent clinical and angiographic results.[10] On the other hand, culotte stenting technique for LM bifurcation lesions was associated with significantly increased rates of MACE and stent thrombosis, compared to DK crush technique in the DKCRUSH-III trial.[11]

The 2-stent technique most similar to the current case is the nano-crush technique, which was proposed by Rigatelli et al.[12] In order to decrease the metallic strut amount in the nano-crush technique, the SB stenting only protrudes one single cell into the main vessel (around 0.5-1 mm), resulted in less MACE when compared to culotte technique in a small, non-randomized, single center study.[13] In the current "carina-crush" technique, the proximal edge of the SB stent was precisely landed at the proximal branching point in order to prevent geographic missing and strut protrusion. The minimally protruding strut at the carina side in current case was crushed but did not fully cover the SB orifice, thus not hindering the dilation of the main vessel stent cell towards the SB. However, it is crucial to find an angiographic projection which can reveal the proximal branching point perfectly, otherwise the technique should not be employed. Of note, in shallow bifurcation angle cases, the current "carina-crush" technique may result in full coverage of the crushed strut as traditional crush technique, and should be further treated accordingly.

In conclusion, we propose a novel "carina-crush" 2-stent technique for treating complex bifurcation lesions which can fully cover the whole bifurcation lesion with only minimal strut overlap. Further observational or even randomized studies are needed to elucidate whether this technique is adequate and promotable.

References

1. Gwon HC. Understanding the coronary bifurcation stenting. *Korean Circ J* 2018;48(6):481-91.
2. Tanabe K, Hoye A, Lemos PA, Aoki J, Arampatzis CA, Saia F, et al. Restenosis rates following bifurcation stenting with sirolimus-eluting stents for de novo narrowings. *Am J Cardiol* 2004;94(1):115-8.
3. Neumann FJ, Sousa-Uva M, Ahlsson A, Alfonso F, Banning AP, Benedetto U, et al. [2018 ESC/EACTS Guidelines on myocardial revascularization]. *Kardiol Pol* 2018;76(12):1585-664.
4. Chen SL, Sheiban I, Xu B, Jepson N, Paiboon C, Zhang JJ, et al. Impact of the complexity of bifurcation lesions treated with drug-eluting stents: the DEFINITION study (Definitions and impact of complEx biFurcation lesIons on clinical outcomes after percutaNeous coronary IntervenTIOn using drug-eluting steNts). *JACC Cardiovasc Interv* 2014;7(11):1266-76.
5. Gao XF, Zhang YJ, Tian NL, Wu W, Li MH, Bourantas CV, et al. Stenting strategy for coronary artery bifurcation with drug-eluting stents: a meta-analysis of nine randomised trials and systematic

review. *EuroIntervention* 2014;10(5):561-9.
6. Behan MW, Holm NR, de Belder AJ, Cockburn J, Erglis A, Curzen NP, et al. Coronary bifurcation lesions treated with simple or complex stenting: 5-year survival from patient-level pooled analysis of the Nordic Bifurcation Study and the British Bifurcation Coronary Study. *Eur Heart J* 2016;37(24):1923-8.
7. Hildick-Smith D, Behan MW, Lassen JF, Chieffo A, Lefevre T, Stankovic G, et al. The EBC TWO Study (European Bifurcation Coronary TWO): A randomized comparison of provisional T-stenting versus a systematic 2 stent culotte strategy in large caliber true bifurcations. *Circ Cardiovasc Interv* 2016;9(9): e003643.
8. Wang J, Guan C, Chen J, Dou K, Tang Y, Yang W, et al. Validation of bifurcation DEFINITION criteria and comparison of stenting strategies in true left main bifurcation lesions. *Sci Rep* 2020;10(1):10461.
9. Ferenc M, Gick M, Comberg T, Rothe J, Valina C, Toma A, et al. Culotte stenting vs. TAP stenting for treatment of de-novo coronary bifurcation lesions with the need for side-branch stenting: the Bifurcations Bad Krozingen (BBK) II angiographic trial. *Eur Heart J* 2016;37(45):3399-405.
10. Erglis A, Kumsars I, Niemela M, Kervinen K, Maeng M, Lassen JF, et al. Randomized comparison of coronary bifurcation stenting with the crush versus the culotte technique using sirolimus eluting stents: the Nordic stent technique study. *Circ Cardiovasc Interv* 2009;2(1):27-34.
11. Chen SL, Xu B, Han YL, Sheiban I, Zhang JJ, Ye F, et al. Clinical outcome after DK crush versus culotte stenting of distal left main bifurcation lesions: The 3-Year follow-up results of the DKCRUSH-III Study. *JACC Cardiovasc Interv* 2015;8(10):1335-42.
12. Rigatelli G, Dell'Avvocata F, Zuin M, Vassiliev D, Mazza A, Dinh HD. Complex coronary bifurcation revascularization by means of very minimal crushing and ultrathin biodegradable polymer DES: Feasibility and 1-year outcomes of the "Nano-crush" technique. *Cardiovasc Revasc Med* 2017;18(1):22-7.
13. Rigatelli G, Zuin M, Vassilev D, Dinh H, Giatti S, Carraro M, et al. Culotte versus the novel nano-crush technique for unprotected complex bifurcation left main stenting: difference in procedural time, contrast volume and X-ray exposure and 3-years outcomes. *Int J Cardiovasc Imaging* 2019;35(2):207-14.