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Letters to the Editor

Double kissing crush in left main coronary bifurcation lesions: A crushing blow to the rival stenting techniques!

"You never know what enough is unless you know what is more than enough".
William Blake (1757–1827)

Left main (LM) bifurcation lesion was no-touch zone for the interventionalists in the past and was considered a surgical domain. Significant unprotected LM disease constitutes approximately 5–7% of patients undergoing coronary angiography[1–3] and more than 80% involve bifurcation. Randomized clinical trials (RCTs) have demonstrated a higher rate of repeat revascularization after percutaneous coronary intervention (PCI) compared with coronary artery bypass grafting (CABG), but a lower incidence of cerebrovascular events; no differences were reported in overall major adverse cardiovascular events (MACEs).[4–9] The 5-year outcome data reported that patients of LM disease with a SYNTAX (Synergy Between Percutaneous Coronary Intervention With TAXUS and Cardiac Surgery) score >33 had lower mortality and a lower rate of repeat revascularization with CABG compared with PCI, thus establishing CABG as the preferred revascularization method.[10] The introduction of newer generation drug-eluting stent (DES) with proven improvements in both safety and efficacy has prompted the design of two new dedicated randomized trials comparing CABG and PCI: the NOBLE (Coronary Artery Bypass Grafting Vs Drug Eluting Stent Percutaneous Coronary Angioplasty in the Treatment of Unprotected Left Main Stenosis) [11] and EXCEL (Evaluation of XIENCE Everolimus Eluting Stent Versus Coronary Artery Bypass Surgery for Effectiveness of Left Main Revascularization).[12] In the EXCEL trial, the composite primary end point of all-cause death, stroke, or myocardial infarction (MI) at 3 years occurred in 15.4% of patients treated with PCI and in 14.7% of patients undergoing CABG. The difference was significant for non-inferiority. In contrast, in the NOBLE trial, treatment with PCI using predominantly a biolimus-eluting stent (Biomatrix Flex, Biosensors) was associated with a significantly higher rate of MACCE at 5 years when compared with CABG. Both studies had a median follow-up duration of 3.1 years, which is relatively short; hence longer term follow-up is needed before any concrete conclusion is drawn. In the EXCEL trial, by the time one gets out over 3 years, death begins to split in favor of CABG. It is going to become statistically significant once the median follow-up is extended up to 5 years.[13] Both PCI and CABG fare quite well when performed by experienced operators at experienced centers. This, in fact, is a testimony to the value of Heart Team approach. Patient discussion should center on risks and benefits of both the procedures and include the important use of long term dual antiplatelet.[13]

The LM represents the largest coronary bifurcation, and stenting techniques are driven by potential complications to the left circumflex coronary artery (LCX) such as acute occlusion and long-term adverse outcomes of target vessel failure and target lesion revascularization (TLR).[14] Intimal atherosclerosis in this bifurcation location is accelerated primarily in area of low shear stress along the lateral wall extending distally on the myocardial walls of the left anterior descending (LAD) and LCX arteries. Involvement of flow divider (carina) is minimal or absent. A long LM (≥ 10 mm) has more pressure drop and lower shear stress contributing to plaque formation.[15] The current trend to treat distal LM bifurcation by extending the main vessel stent into the proximal LAD is supported by continuous extension of plaque from LM to proximal LAD artery in 90% of cases.[16]

However, anatomically easy accessibility and large caliber make LM PCI an attractive choice for interventionalists.[17] Treatment of ostial and mid-shaft has shown excellent outcomes with minimal mortality and long-term complications compared with LM bifurcations.[18] The technical innovation in PCI and stent technology have emboldened the interventionalists to test the feasibility of PCI of LM bifurcation lesions. Lack of RCTs addressing LMCA bifurcation has led to uncertainties regarding optimal stenting strategy. Although the provisional one-stent technique has been the default strategy based on non-randomized studies and extrapolations from results of non-LM bifurcation trials, two-stent techniques are selected more frequently for LM bifurcation than non-LM.[19] The stenting technique selection depends on plaque distribution, size of the main branch (MB) and the side branch (SB), severity and length of SB lesion, bifurcation angulation and the operator experience/expertise.Various two-stent techniques have emerged with names that reflect their configuration, such as T stenting, modified T stenting, V stenting, simultaneous kissing stenting, crush, mini crush, step crush, culotte and double kissing (DK) crush. Individual two-stent techniques have been validated, but evidence from random comparisons pitting various techniques against each other is largely lacking. DEFINITION criteria.[20] stratifies LM bifurcation as simple if SB diameter stenosis is <70% and lesion length <10 mm. This is seen in 75% of cases and can be treated with a provisional one-stent technique. It is designated as complex if SB diameter stenosis is >70% and lesion length >10 mm. A simple lesion becomes complex when 2 of the 6 following minor criteria are present. 1) moderate to severe calcification; 2) bifurcation angle >70°; 3) main branch (MB) diameter <2.5 mm; 4) multiple lesions; 5) presence of thrombus; 6) MB lesion length >25 mm. Complex lesions usually require a two-stent strategy. There is, however, no consensus on the best two stent techniques. The crush and culotte techniques were introduced to optimize scaffolding and drug application to the SB ostium, a common site for restenosis.[21,22]

Potential reasons for primary or secondary failure of SB stenting are lack of ostial scaffolding, carina shift, crushing of the proximal segment of SB stent without, or even after, kissing balloon inflation, which may result in malapposition and inefficiency of the DES. To overcome these shortcomings, especially incomplete SB ostial coverage, the crush

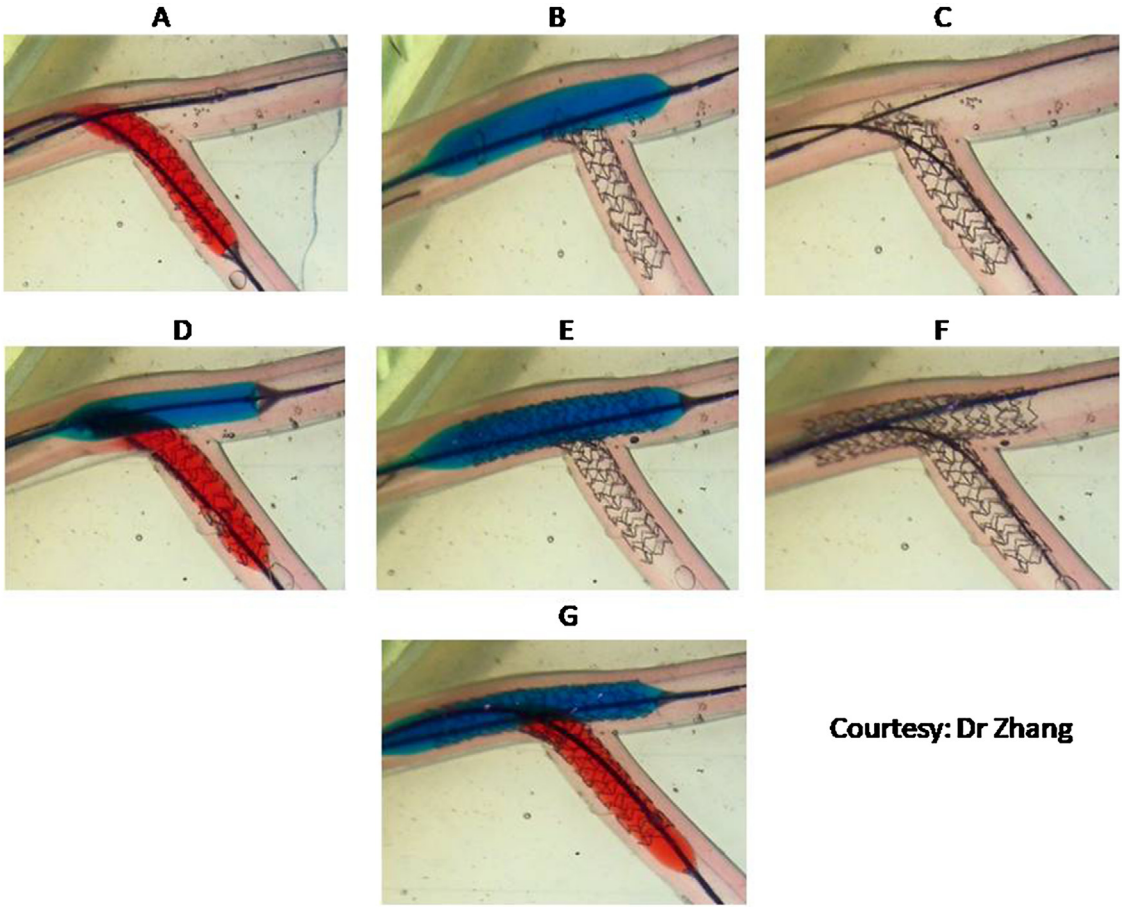

Fig. 1. Left sub-clavian arterial angiogram showing thrombus.

technique,[23] proposed first by Colombo and coworkers, met the need to scaffold SB ostium. There are still unsatisfactory results if final kissing balloon inflation (FKBI) is undertaken with a smaller diameter balloon than the previous stenting balloon. As a result, correct FKBI is a useful adjunct and served to repair stent distortion and cover the orifice of SB.[24] An unsatisfactory and incomplete FKBI (20–25% after classic crush) is associated with high rate of stent thrombosis (ST) and in-stent-restenosis (ISR). The bench test attributes this kissing failure to stent platform, irregular and small stent cell, severe distortion of MB stent, and the irregular overlapping of three layers of stent struts.[25] DK crush technique introduced by Chen et al employs kissing balloon inflation twice to overcome shortcomings of classical crush technique.[26] It includes the following steps: SB stenting with 2 to 3 mm protrusion into MB, SB stent crush by MB balloon, first kissing, MB stenting, and FKBI. After balloon crush of the deployed SB stent, there remains two layers of struts from SB ostium to the MB. First kissing optimizes the distorted SB stent and leave only one layer of stent struts at SB ostium, which facilitates second kissing after MB stenting. First kissing restores the shape of bifurcation anatomy by minimizing repeated SB ostial distortion while inflating MB. It is important that the interventionalists rewire SB from the proximal stent cell to prevent abluminal wiring and SB ostial gap (Figs. 1 and 2). Clinical data, comparing DK crush with either classic crush or other stenting techniques, evolved mainly from the serial randomized DK crush trials. DK crush has several advantages over classic crush such as shorter procedural time, less contrast use, and most importantly, 100% success with FKBI (compared to 80% in the classic crush.[26] DK CRUSH-I study demonstrates that DK crush stenting significantly reduces of ST, ISR, and MACE in patients treating with true bifurcation lesions compared to classical crush.[27] DK crush reduced significantly rate of TLR compared to provisional T-stenting technique in complex bifurcation lesion in the DK CRUSH II trial.[28] This trial included complex true bifurcation lesions with significantly diseased SB having a mean lesion length of 15 mm (much longer than in other randomized studies where the majority were <10 mm). FKBI was achieved in 100% of those treated with DK crush. These results would suggest that DK crush technique is a superior strategy and should be employed in preference to provisional T-stenting for most complex lesions with a relatively long length of significant SB disease (i.e. LM bifurcation). DK crush even bested the culotte method in patients with complex LM bifurcation lesions in the DKCRUSH-III randomized trial. More than twice as many patients in the culotte group experienced MACE at 1 year compared with the DK crush group (16.3% versus 6.2%, $p < 0.05$). Even three years clinical outcomes were in favor of DK crush compared to culotte stenting.[29,30] A bench study reports that a "napkin" or a gap usually exits at SB ostium after culotte stenting, leading to failure tofully scaffold the ostial SB and resulting in increased ISR, TLR, and ST. [31] The absence of definite and probable ST at 3-year follow-up after DK crush stenting suggests the importance of stenting techniques in improving the safety of LM bifurcation PCI. The introduction of first kissing may improve stent expansion. Furthermore, alternative high pressure inflation followed by second kissing and proximal optimization maintain a better stent apposition. Subsequently, less metal overlap, fully ostial SB stent apposition, and less stent distortion achieved in DK crush correlates with improved clinical outcomes (Table 1). In the DK crush V randomized trial, PCI of true distal LM bifurcation lesions using a planned DK crush strategy resulted in a lower rate of target lesion failure at 1 year than a provisional stenting strategy.[32] The ongoing

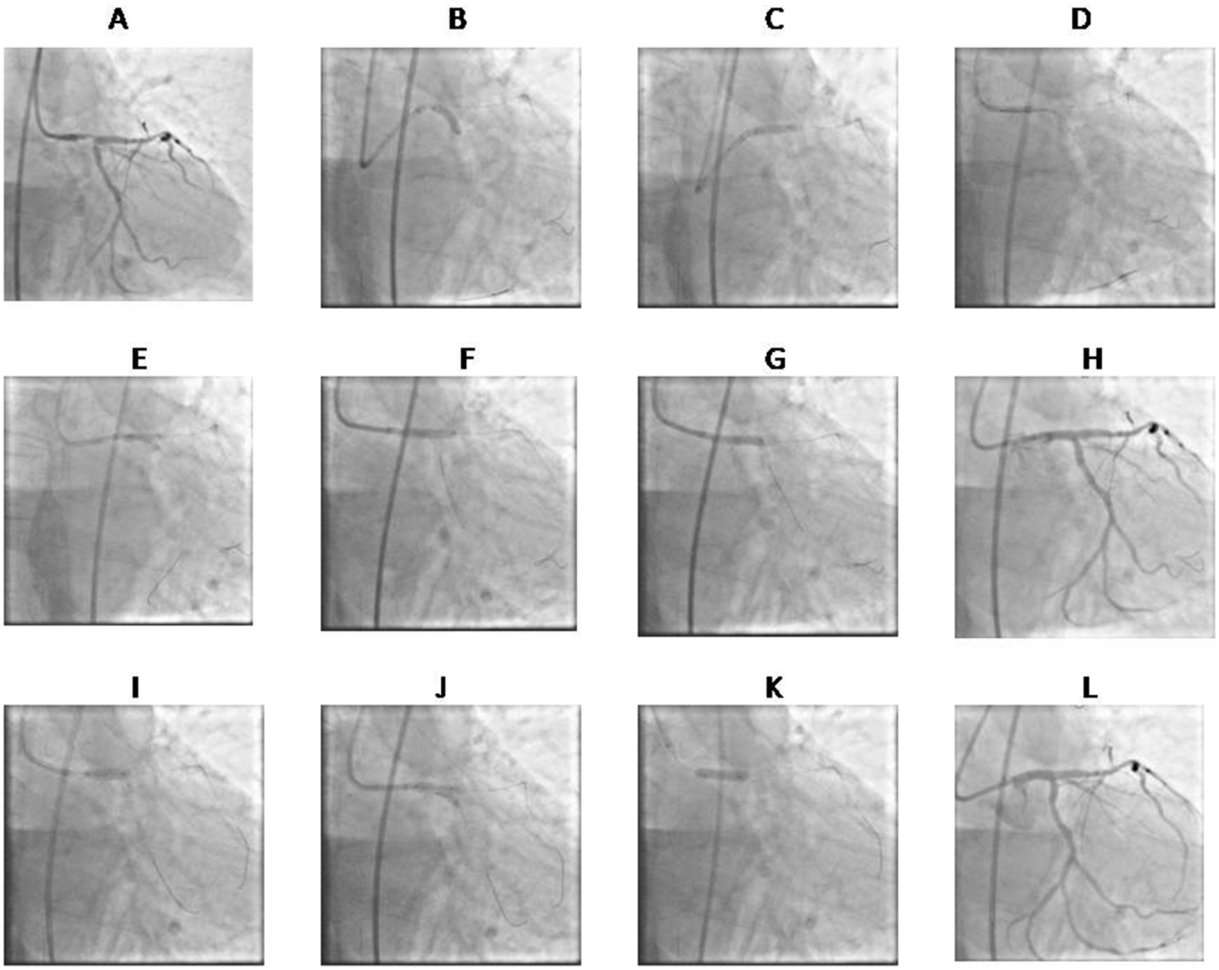

Fig. 2. A. Coronary angiogram depicting Medina 1,1,1 left main (LM) bifurcation lesion; B. Navigation of guidewires into main branch left anterior descending (LAD) and side branch left circumflex (LCX) artery, predilatation of LCX by 3 × 15 mm complaint balloon followed by 3.5 × 18 mm DES implantation with 2-3 mm protrusion into LAD; C. Inflation of 3 × 15 mm complaint balloon in LAD crushing the LCX stent; D. First SB (LCX) rewiring through proximal cell; E. First kissing balloon inflation of LAD and LCX using 3.5 × 15 mm non-compliant balloon; F. Implantation of 3.5 x 18 mm DES in LAD; G. Proximal optimization technique of LAD using 3.5 x 15 mm non-complaint balloon; H. Second rewiring of LCX through proximal cell; I. Sequential high pressure post dilatation of LCX and LAD using non-compliant balloon; J. Second kissing balloon inflation of LAD and LCX using 3.5 × 15 mm non-compliant balloon; K. Re-POT of LAD using 3.5 x 15 mm non-complaint balloon; L. Final result.

DEFINITION II, a prospective, multicenter, randomized, controlled, superiority clinical trial at 45 sites worldwide to enroll 660 patients with bifurcation lesion may further likely shed light on superiority of techniques used (provisional vs two-stent approach).[33]

It is surprising to note that DK crush technique has not gained widespread acceptance. The author feels frustrated at the inability to always perform FKBI while adopting classical crush technique. This is further compounded by the adverse clinical outcomes such as ST and ISR. If the word "crush" has prevented us from adopting DK crush, the hesitancy should be overcome by looking into the uniformly positive data from the DK crush trials. The technique is straightforward, reliable, safe and effective for complex LM bifurcation lesions (as defined by DEFINITION criteria)[20] and with all bifurcation angles. V stenting, simultaneous kissing stents, mini

Table 1
Comparison of double kissing (DK) crush with classical crush stenting technique.

	DK crush	Classical crush
Guide catheter	6F	7F
Anatomy	Suitable for all bifurcation angles	Unsuitable for wide angled bifurcation
Procedure type	Straightforward and reliable	Complex
Procedure time	Short	Longer than DK crush
Contrast use	Less	More
First kissing balloon inflation	Done	Not done
Final kissing balloon inflation	100%	70-80%
Kiss quality	Satisfactory	Unsatisfactory (abluminal side branch wiring)
Metal overlap	Less (Two layers)	More (3 layers)
Side branch ostial scaffolding	Full	Incomplete
Stent thrombosis & in-stent restenosis	Negligible	Significant

crush, culotte technique may not be suitable in wide angled (≥70°) bifurcations. The day is not far when DK crush technique is going to supplant other stenting techniques and becomes sine-qua-non in the treatment of LM bifurcation.

Conflict of interest

None.

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de Winter sign–A STEMI Equivalent

Dear Editor,

A 63-years-old male with a history of heavy smoking presented to us with severe retrosternal chest pain of 1 h duration. The patient was hemodynamically stable. The 12-lead ECG obtained at admission showed ST-segment depression (1 mm) at the J-point, with tall, symmetrical T-waves in the precordial leads along with ST-segment elevation (0.5–1 mm) in the lead avR (Fig. 1). These findings suggested electrocardiographic de Winter sign. This sign is a marker of acute occlusion of the left anterior descending (LAD) coronary artery and is helpful in diagnosing anterior wall ST elevation myocardial infarction (STEMI) even in the absence of ST-segment elevation in the precordial leads.[1] Fortunately, we were able to recognise this entity timely and subjected the patient to emergency primary percutaneous coronary intervention (PCI). On coronary angiography, there was total thrombotic occlusion of the LAD after the first diagonal (Figs. 2 and 3). Left circumflex coronary