

EDITORIAL COMMENT

Unmatched Results After Double Kissing Crush Stenting Technique in Distal Left Main Coronary Artery Treatment?*



Leif Thuesen, MD, DMSc,[†] Niels Ramsing Holm, MD[‡]

In the past, the left main coronary artery (LMCA) was a no-touch zone for the interventional cardiologist. LMCA treatment was a surgical domain; coronary artery bypass graft reduced mortality as compared with medical treatment. Experience with bailout stenting of LMCA dissection complicating diagnostic and interventional procedures, interventions in acute and subacute coronary syndromes, and LMCA procedures in high operative risk patients showed that these lesions might be treated less invasively with excellent immediate and longer-term results.

Meta-analyses of percutaneous coronary intervention (PCI) versus coronary artery bypass graft LMCA studies, but first and foremost the SYNTAX (Synergy Between Percutaneous Coronary Intervention With Taxus and Cardiac Surgery) trial (1) with 5-year data on a pre-specified subgroup of 705 LMCA patients, documenting equality between surgical and PCI in low and medium SYNTAX score patient groups, have been influential in the latest European (2) and American guidelines (3) on LMCA revascularization. There are now Class I, Level of Evidence: A (2) and Class II, Level of Evidence: A (3,4) recommendations for treatment of low-risk LMCA lesions by PCI. The more complex lesion subset requiring a 2-stent LMCA bifurcation treatment holds a Class II, Level of Evidence: B (3,4) recommendation for PCI. However, studies with

extended follow-up of >5 years are required to provide definitive conclusions about the optimal LMCA treatment (4). Hopefully, the EXCEL (Evaluation of XIENCE PRIME Everolimus Eluting Stent System [EECSS] or XIENCE V EECSS or XIENCE Xpedition EECSS or XIENCE PRO EECSS Versus Coronary Artery Bypass Surgery for Effectiveness of Left Main Revascularization) and the NOBLE (Nordic-Baltic-British Left Main Revascularization Study) trials, which will be reporting results in the Fall of 2016, will be able to answer these questions.

Ahead of international recommendations, stenting is the preferred primary treatment of all aspects of LMCA disease in many heart centers, and the optimal LMCA stenting technique is of major clinical interest.

SEE PAGE 1335

In this issue of *JACC: Cardiovascular Interventions*, Chen et al. (5) convey 3-year results of the DKCRUSH-III (Double Kissing Crush Versus Provisional Stenting Technique for Treatment of Coronary Bifurcation Lesions III) trial randomizing 415 patients with distal LMCA stenosis to the double kissing crush (DK-crush) versus the culotte 2-stent bifurcation techniques. Their findings were much in favor of the DK-crush approach. The 3-year major adverse cardiac event rates were 8.2% versus 23.7% ($p < 0.001$), myocardial infarction 3.4% versus 8.2% ($p = 0.037$), and TVR 5.8% versus 18.8% ($p < 0.001$) after DK-crush and culotte treatment, respectively. Furthermore, definite or probable stent thrombosis did not occur in DK-crush treated patients, but it did occur in 3.9% in the culotte group.

All patients had “true” bifurcation lesions and about 29% of patients had increased lesion complexity according to the DEFINITION (Definitions and Impact of Complex Bifurcation Lesions on Clinical

*Editorials published in *JACC: Cardiovascular Interventions* reflect the views of the authors and do not necessarily represent the views of *JACC: Cardiovascular Interventions* or the American College of Cardiology.

From the [†]Department of Cardiology, Aalborg University Hospital, Aalborg, Denmark; and the [‡]Department of Cardiology, Aarhus University Hospital, Skejby, Aarhus, Denmark. Dr. Holm has received institutional research grants from Cordis, Abbott, St. Jude Medical, and Terumo; and has received speaking fees from St. Jude Medical and Terumo. Dr. Thuesen has reported that he has no relationships relevant to the contents of this paper to disclose.

Outcomes After Percutaneous Coronary Intervention Using Drug-Eluting Stents) classification (6). The vast majority of clinical events in both treatment groups occurred in the high-risk lesion subset, thereby defining a high-risk population of particular interest and a low-risk population with excellent clinical outcome. The culotte group has a particularly high major adverse cardiac event rate of 51.5% versus 15.1% in the high-risk lesion subset.

The DK-CRUSH investigators introduced the DK-crush 2-stent technique for bifurcation treatment in 2005. Basically, the technique consists of 5 steps: side branch (SB) stenting; balloon-crush of the SB stent; first kissing balloon inflation; second crush using the main vessel stent; and final kissing balloon inflation (7).

Early invasive imaging studies indicated that DK-crush resulted in larger SB opening and improved SB stent expansion than classic crush did, and the initial clinical experience indicated a high success rate of the final kissing balloon inflation. Subsequently, the DK-crush technique has been validated by the same investigators in 3 randomized clinical trials showing favorable outcomes in comparison to classic crush (DKCRUSH-I), to provisional SB stenting (DKCRUSH-II), and now superior 3-year outcome in comparison to culotte stenting in distal LMCA lesions; the DKCRUSH-III (DKCrush Versus Culotte Stenting for the Treatment of Unprotected Distal Left Main Bifurcation Lesions) study (7-9).

The DKCRUSH-III trial is a high-quality study, is well powered, has almost 100% 3-year follow-up, and has multicenter and multicountry participation. The 3-year DKCRUSH-III results are remarkable: considerably lower PCI event rates than in the SYNTAX trial. A similar pattern was seen in DKCRUSH-I and -II with very low event rates in the DK-crush groups as compared with other bifurcation stent technique studies. This raises the question whether the DK-crush technique is better than the prevalent culotte and mini crush techniques and the provisional SB treatment strategy in managing LMCA and other coronary bifurcation lesions.

The DK-crush versus culotte technique superiority was primarily related to new target lesion revascularizations and myocardial infarctions. It is unclear to what extent these events were related to the pre-scheduled 8-month angiographic control, but the event curves seem to start separating after 8 months. Furthermore, it is unclear whether the myocardial infarctions were procedure related and specifically related to new target lesion revascularizations. The new revascularizations were mandated by clinical signs of ischemia, but, as in other nonblinded studies,

there is a risk of bias in a study-mandated angiography and potentially a lower threshold to perform non-pre-scheduled angiographic follow-up.

The DK-crush technique involves more balloon inflations, which may improve lesion preparation, facilitates SB rewiring, and results in a very high success rate of final kissing balloon inflation. The high success rate of final kissing balloon inflation is a clear advantage of the DK-crush technique. Particularly, in comparison to mini crush, where final kissing balloon inflation success is low, the risk of leaving the circumflex coronary artery jailed by 2 strut layers supports the use of the DK-crush implantation technique.

As compared with the culotte technique with double stent strut layers in the proximal part of the main vessel, the DK-crush has a single stent layer in the main vessel, but potentially 3 layers of struts just proximal to the SB ostium. Multiple strut layers may affect healing and increase the risk of stent thrombosis. Furthermore, the subsequent main vessel stent implantation is not restricted by the cell-opening as in culotte, where a cigar-belt effect may be pronounced and may increase the risk of malapposition and insufficient vessel expansion in both the ostium of the distal main vessel and the SB.

In DK-crush, the main vessel does not require rewiring. This is an attractive feature as compared with the culotte technique, especially in cases that require stenting the circumflex artery first and substantial ostial left anterior descending residual stenosis after pre-dilation. Furthermore, the position of SB recrossing has been shown to affect scaffolding and degree of malapposition after kissing balloon inflation (10). In the DK-crush technique, only the SB may be affected by a suboptimal recrossing, whereas in culotte, there is a risk of rewiring through a stent cell opposite the carina during wiring of both vessels. On the other hand, the risk of abluminal rewiring of the SB stent during DK-crush procedures is probably not reduced as compared with the risk with the culotte technique.

The excellent clinical results following DK-crush bifurcation stenting of distal LMCA lesions are promising for the interventional treatment of this important lesion subset. A randomized comparison of DK-crush and coronary artery bypass graft is probably wishful thinking, but it should be perfectly possible for other groups of investigators to confirm the results reported in DKCRUSH-III.

REPRINT REQUESTS AND CORRESPONDENCE: Dr. Leif Thuesen, Department of Cardiology, Aalborg University Hospital, Hobrovej 8-10, 9100 Aalborg, Denmark. E-mail: leif.thuesen@ki.au.dk.

REFERENCES

1. Mohr FW, Morice MC, Kappetein AP, et al. Coronary artery bypass graft surgery versus percutaneous coronary intervention in patients with three-vessel disease and left main coronary disease: 5-year follow-up of the randomised, clinical SYNTAX trial. *Lancet* 2013;381:629-38.
2. Windecker S, Kolh P, Alfonso F, et al. 2014 ESC/EACTS Guidelines on myocardial revascularization: the Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). *Eur Heart J* 2014;35:2541-619.
3. Fihn SD, Gardin JM, Abrams J, et al. 2012 ACCF/AHA/ACP/AATS/PCNA/SCAI/STS guideline for the diagnosis and management of patients with stable ischemic heart disease: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines, and the American College of Physicians, American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. *J Am Coll Cardiol* 2012;60:e44-164.
4. Fihn SD, Blankenship JC, Alexander KP, et al. 2014 ACC/AHA/AATS/PCNA/SCAI/STS focused update of the guideline for the diagnosis and management of patients with stable ischemic heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines, and the American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. *J Am Coll Cardiol* 2014;64:1929-49.
5. Chen S-L, Xu B, Han Y-L, 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. *J Am Coll Cardiol Intv* 2015;8:1335-42.
6. Chen SL, Sheiban I, Xu B, 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). *J Am Coll Cardiol Intv* 2014;7:1266-76.
7. Chen SL, Xu B, Han YL, et al. Comparison of double kissing crush versus culotte stenting for unprotected distal left main bifurcation lesions: results from a multicenter, randomized, prospective DKCRUSH-III study. *J Am Coll Cardiol* 2013;61:1482-8.
8. Chen SL, Zhang JJ, Ye F, et al. Study comparing the double kissing (DK) crush with classical crush for the treatment of coronary bifurcation lesions: the DKCRUSH-1 Bifurcation Study with drug-eluting stents. *Eur J Clin Invest* 2008;38:361-71.
9. Chen SL, Santoso T, Zhang JJ, et al. A randomized clinical study comparing double kissing crush with provisional stenting for treatment of coronary bifurcation lesions: results from the DKCRUSH-II (Double Kissing Crush versus Provisional Stenting Technique for Treatment of Coronary Bifurcation Lesions) trial. *J Am Coll Cardiol* 2011;57:914-20.
10. Alegria-Barrero E, Foin N, Chan PH, et al. Optical coherence tomography for guidance of distal cell recrossing in bifurcation stenting: choosing the right cell matters. *EuroIntervention* 2012;8:205-13.

KEY WORDS coronary bifurcation, coronary revascularization, coronary stent(s), left main coronary artery, percutaneous coronary intervention