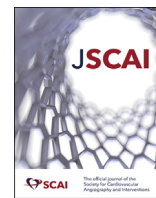




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Editorial

Treatment Strategies for Coronary Bifurcation Lesions: Complexity and Risk

Brittany M. Owen, MD, H. Vernon ('Skip') Anderson, MD*

University of Texas Health Science Center, McGovern Medical School, Memorial Hermann Heart & Vascular Institute, Houston, Texas



Continuing improvements in several technologies used in percutaneous coronary intervention (PCI) have led to increased attempts to treat more complex coronary lesions of all types. This includes PCI attempts on coronary bifurcations, which are some of the most challenging types in the complex lesion class. All complex lesions, including coronary bifurcations, are associated with worse immediate and long-term outcomes than simple lesions.¹

The increased risk with coronary bifurcation lesions has led to a longstanding debate on their treatment: at what point is it necessary to treat the side branch (SB) in addition to the main vessel (MV)? Two schools of thought exist: a provisional stent placement strategy, in which the MV is treated and the SB is left alone unless threatened or actual closure occurs, in which case the SB is also treated, or, alternatively, a dedicated 2-stent strategy in which the treatment of both the MV and SB is planned from the beginning.

In this issue of *JSCAI*, Fujisaki et al² present a meta-analysis of 13 randomized control trials (RCTs) comparing provisional with dedicated bifurcation stent placement using one of the several possible PCI techniques. An important feature of this work is the inclusion of RCTs using mostly or exclusively second-generation drug-eluting stents. Earlier meta-analyses of bifurcation PCI included studies using bare metal stents or first-generation drug-eluting stents, which are now obsolete; we agree that it is preferable to use only contemporary data for developing insights into future approaches.

These authors found that the double-kissing (DK) crush technique was superior to alternative 2-stent techniques, such as T-stent placement and culotte, whenever a 2-stent strategy was used, with significant reductions in target lesion revascularization and major adverse cardiovascular events observed in favor of DK crush. These findings regarding the DK crush technique are similar to those reported previously,³⁻⁵ and although the role played by stent generation is not clear, this point is moot since older generation stents are no longer used.

Of interest, the authors also conclude that a dedicated 2-stent strategy is superior to a provisional strategy. On the surface, this seems to contradict current recommendations that favor a provisional strategy for bifurcation lesions; however, the findings here are less surprising on a deeper analysis. The critical determining points are the following: left

main versus nonleft main bifurcations, relative sizes of the MV and SB, and the "complexity" of disease in the SB (especially lesion length).

In part, this conclusion is influenced by trial design. For example, the DKCRUSH-III,⁶ DKCRUSH-V,⁷ SMART STRATEGY II,⁸ and EBC MAIN⁹ trials included only left main bifurcations, whereas the study by Ruiz et al,¹⁰ PERFECT,¹¹ and the EBC TWO¹² excluded left main bifurcations. Corresponding to this grouping, 4 trials involving left main bifurcations had larger MV and SB diameters than the 3 trials involving nonleft main bifurcations (approximately 3.5-4.0 mm MV diameters with 3.0 mm SB diameters compared with approximately 3.0 and 2.7 mm, respectively). Because lesion management will be influenced by vessel size, future analyses should stratify for left main versus nonleft main bifurcations.

In addition, there were large differences in SB lesion lengths in the 13 trials, ranging from an average of 6.0 to 22.0 mm, and in almost all cases, the SB lesion was long enough to be considered "complex" by DEFINITION-II criteria.¹³ Several of the trials required SB lesion lengths >5.0 mm for a patient to be eligible for inclusion, whereas other trials did not have this requirement. These differences illustrate how crucial patient selection is to RCT results.

The importance of focusing on SB lesion complexity resides in the fact that many previous investigators have reported superior outcomes with a 2-stent strategy compared with those of a provisional strategy in complex bifurcation lesions.¹³ Moreover, a recent review of the evolution of the DK crush technique noted the growing recognition of the superiority of a dedicated 2-stent strategy compared with that of a provisional strategy in treating complex bifurcation lesions.⁴ Therefore, the meta-analysis by Fujisaki et al² provides a strong additional support for this conclusion, inasmuch as most of the SB lesions included in the trials in their meta-analysis were complex.

The question then remains: What are the criteria for SB lesions to be considered "complex"? Fortunately, we now have guidance on this and other important questions for consideration in future studies. The Bifurcation Academic Research Consortium (Bif-ARC) recently published a set of definitions and standards for investigating treatments of bifurcation lesions.¹⁴ These recommendations include standards for lesion complexity. Vessel size, distribution, and relevance/importance of the SB are among the critical factors for categorizing complexity, as are the

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* Corresponding author: h.v.anderson@uth.tmc.edu (H.V. Anderson).

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presence and extent of calcification, thrombus, and lesion geometry. Going forward, the application of these standards in clinical trial designs should facilitate the interpretation of their pooled or combined results, which may help generate new knowledge regarding when provisional strategies or dedicated 2-stent strategies are appropriate. It is likely there is gradation in the SB lesion risk. At the upper levels of risk (complex SB), a dedicated 2-stent strategy will be superior. At the lower levels of risk (non-complex SB—still to be precisely defined), a provisional strategy may be equivalent or even superior.

The meta-analysis by Fujisaki et al. reaffirms several concepts. First, newer generation stents, along with improved guide wires, support catheters, adjunctive therapies, and imaging, have led to improved 2-stent strategies for the treatment of coronary bifurcation lesions. Second, the DK crush technique seems to be superior to other alternatives for complex lesion subsets. Finally, a dedicated 2-stent strategy seems superior to a provisional strategy in complex bifurcations, but whether a 2-stent strategy will prove better in “noncomplex” bifurcations remains an open question.

Declaration of competing interest

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References

- Mohamed MO, Polad J, Hildick-Smith D, et al. Impact of coronary lesion complexity in percutaneous coronary intervention: one-year outcomes from the large, multicentre e-Ultimaster registry. *EuroIntervention*. 2020;16(7):603–612. <https://doi.org/10.4244/EIJ-D-20-00361>
- Fujisaki T, Kuno T, Numasawa Y, et al. Provisional or 2-stent technique for bifurcation lesions in the second-generation drug-eluting stent era. *J Soc Cardiovasc Angiogr Interv*. 2022;1(5):100410.
- Di Gioia G, Sonck J, Ferenc M, et al. Clinical outcomes following coronary bifurcation PCI techniques: a systematic review and network meta-analysis comprising 5,711 patients. *JACC Cardiovasc Interv*. 2020;13(12):1432–1444. <https://doi.org/10.1016/j.jcin.2020.03.054>
- Raphael CE, O’Kane PD, Johnson TW, et al. Evolution of the crush technique for bifurcation stenting. *JACC Cardiovasc Interv*. 2021;14(21):2315–2326. <https://doi.org/10.1016/j.jcin.2021.08.048>
- Elbadawi A, Shnoda M, Dang A, et al. Meta-analysis comparing outcomes with bifurcation percutaneous coronary intervention techniques. *Am J Cardiol*. 2022;165:37–45. <https://doi.org/10.1016/j.amjcard.2021.10.048>
- 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(14):1482–1488. <https://doi.org/10.1016/j.jacc.2013.01.023>
- Chen X, Li X, Zhang JJ, et al. DKCRUSH-V Investigators. 3-Year outcomes of the DKCRUSH-V trial comparing DK Crush with provisional stenting for left main bifurcation lesions. *JACC Cardiovasc Interv*. 2019;12(19):1927–1937. <https://doi.org/10.1016/j.jcin.2019.04.056>
- Kim J, Lee JM, Park TK, et al. Optimal strategy for side branch treatment in patients with left main coronary bifurcation lesions. *Rev Esp Cardiol*. 2021;74(8):691–699. <https://doi.org/10.1016/j.rec.2020.06.011>
- Hildick-Smith D, Egred M, Banning A, et al. The European bifurcation club left main coronary stent study: a randomized comparison of stepwise provisional vs. systematic dual stenting strategies (EBC MAIN). *Eur Heart J*. 2021;42(37):3829–3839. <https://doi.org/10.1093/eurheartj/ehab283>
- Ruiz-Salmerón RJ, Valenzuela LF, Pérez I, et al. Approach to coronary bifurcation lesions using the everolimus-eluting stent: comparison between a simple strategy and a complex strategy with T-stenting. *Rev Esp Cardiol*. 2013;66(8):636–643. <https://doi.org/10.1016/j.rec.2013.03.005>
- Kim YH, Lee JH, Roh JH, et al. Randomized comparisons between different stenting approaches for bifurcation coronary lesions with or without side branch stenosis. *JACC Cardiovasc Interv*. 2015;8(4):550–560. <https://doi.org/10.1016/j.jcin.2015.01.016>
- Hildick-Smith D, Behan MW, Lassen JF, 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. <https://doi.org/10.1161/CIRCINTERVENTIONS.115.003643>
- Zhang JJ, Ye F, Xu K, et al. Multicentre, randomized comparison of two-stent and provisional stenting techniques in patients with complex coronary bifurcation lesions: the DEFINITION II trial. *Eur Heart J*. 2020;41(27):2523–2536. <https://doi.org/10.1093/eurheartj/ehaa543>
- Lunardi M, Louvard Y, Lefèvre T, et al. Definitions and standardized endpoints for treatment of coronary bifurcations. *J Am Coll Cardiol*. 2022;80(1):63–88. <https://doi.org/10.1016/j.jacc.2022.04.024>