

Strategies for DESs in Bifurcation Disease

Recent achievements in percutaneous coronary interventions have led to lower restenosis rates.

BY SAMIN K. SHARMA, MD, FACC

Coronary bifurcations are prone to develop atherosclerotic plaque due to turbulent blood flow and high shear stress. These lesions amount to 15% to 20% of the total number of coronary interventions. The true bifurcation lesion consists of >50% diameter obstruction of the main vessel (MV) and of the side branch (SB) in an inverted Y fashion.

Treatment of coronary bifurcation lesions represents a challenging area in interventional cardiology, but recent advances in percutaneous coronary interventions (PCIs) have led to the dramatic increase in the number of successfully treated PCI patients. When compared with nonbifurcation interventions, bifurcation interventions have a lower rate of procedural success, higher procedural costs, longer hospitalization, and higher clinical and angiographic restenosis rates.¹ The introduction of drug-eluting stents (DESs) has resulted in a lower event rate and reduction of MV restenosis in comparison with historical controls. However, SB ostial residual stenosis and long-term restenosis remain a problem.

ANATOMICAL CLASSIFICATION

Coronary bifurcations have been classified according to the angulation between the MV and the SB and according to the location of the plaque burden. The bifurcations are classified based on the SB angulation. In Y angulation, when the angulation is <70°, access to the SB is usually easy, but plaque shifting is more pronounced, and precise stent placement in the ostium is difficult. In T angulation, when the angulation is >70°, access to the SB is usually more difficult, but plaque shifting is often minimal, and precise stent placement at the ostium is easier. Regarding plaque distribution, there have been numerous attempts to categorize bifurcations, with three classification patterns commonly used: Duke classification (most commonly used), Lefevre clas-

sification, and Medina classification.² These classifications do not take into account what happens to the SB on dilatation of the MV, and therefore, lesions alone in the SB or the MV may convert into a true Y bifurcation due to plaque shift or stent protrusion during coronary intervention. Consequently, each lesion must be approached therapeutically in the context of its own anatomy and operator experience.

ONE STENT VERSUS TWO FOR BIFURCATION LESIONS

The strategies to use one stent (in the MV) or two stents (one in the MV and one in the SB) to treat bifurcation lesions have been long debated (Figure 1).³⁻⁵ The most important initial question is whether the SB is large enough (>2.25 mm to 2.5 mm) with a sufficient territory of distribution to justify stent implantation or even balloon dilatation, irrespective of the bifurcation pattern. If the SB is small (<2 mm) and supplying a small area of myocardium, then it should be ignored during PCI, and a stent can be placed in the MV, across the SB. This strategy is defined as provisional SB stenting/angioplasty. A recent randomized trial compared use of one DES (Cypher, Cordis Corporation, a Johnson & Johnson company, Miami, FL) versus two DESs in the treatment of coronary bifurcation lesions.⁶ This study revealed that although both techniques resulted in low angiographic restenosis of the MV (approximately 5%), routine stenting of the SB (two stents) was associated with a trend toward higher restenosis in the SB (23% vs 14%; $P=.22$) and insignificantly higher overall target lesion revascularization (TLR) (9.5% vs 4.5%; $P=.42$). The Nordic Bifurcation Study also revealed equivalent low TLR (<5% at 9-month follow-up with one-stent vs two-stent technique), with higher non-Q-wave MI, procedure time, and contrast use with the two-stents technique. There was no difference in stent thrombosis rates between the two strategies.⁷

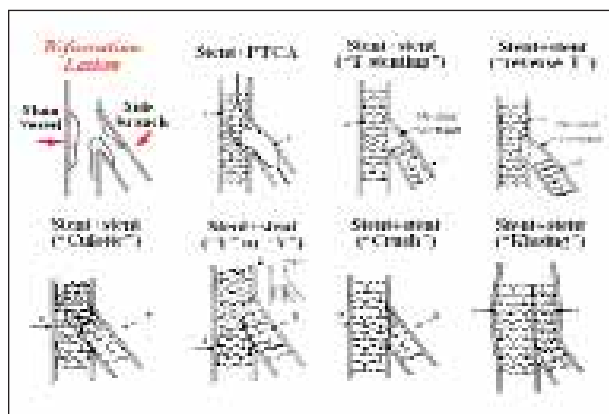


Figure 1. Commonly used techniques for treating bifurcation lesions.

ONE STENT BY INTENTION TO TREAT

Conventional (provisional) SB-stenting technique. The most common approach in the treatment of bifurcations is stenting only the MV and provisional stenting of the SB, if needed, for suboptimal angiographic results before or after stent deployment in the MV. If the result at the SB remains unsatisfactory, the operator can still decide to stop because the SB is not ideal for stenting due to difficulty in positioning a stent, size, distal runoff, complexity of the procedure, and so on. If the decision is made to improve the result at the level of the SB, stenting is then performed according to the reverse T approach, advancing the stent via the MV stent struts with final kissing-balloon dilatation.

TWO STENTS BY INTENTION TO TREAT

Several two-stent techniques are available, with various levels of complexity and indications: the V technique, the simultaneous kissing stents (SKS) technique, the crush technique and its variations (reverse and step), the T technique and its variation (modified), the culotte technique, and the Y technique.

The V and SKS Techniques

The V technique consists of the delivery and implantation of two stents together. One stent is advanced in the SB, the other in the MV, and the two stents touch each other, forming a small proximal carina (<2 mm).

When the carina extends a considerable length (usually ≥ 3 mm) into the MV, this technique is called SKS. The types of lesions most suitable for this technique are proximal lesions, such as distal left main bifurcation and other bifurcations with moderate-to-large SB (>2.75 mm), and the vessel portion proximal to bifurcation is free of disease.

The SKS technique (Figure 2) involves using two appropriately sized stents (stent-to-artery ratio, 1:1), one for the MV and one for the SB, with an overlap of the two stents in

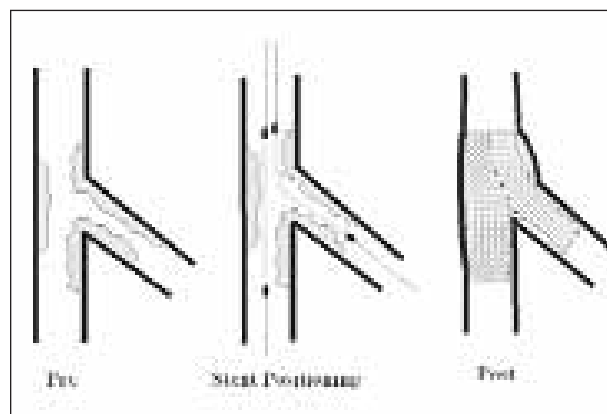


Figure 2. The SKS technique uses two stents and builds a proximal new carina.

the proximal segment of the MV (stent sized 1:1 to the MV after the bifurcation). The proximal part of the MV should be able to accommodate the two stents, and its size should be approximately two thirds of the aggregate diameter of the two stents. For example, for two 3-mm stents in the left anterior descending artery and the diagonal branch, the proximal MV size should be approximately 4 mm. Stent lengths are selected visually to cover the entire length from the distal end of the SB and MV lesions to the proximal end in the MV. A 7-F or 8-F guide catheter (internal diameter >.78 inch) is used. Debulking using a cutting balloon or Rotablator (Boston Scientific Corporation, Natick, MA), with or without balloon angioplasty, of the MV and/or of the SB, is performed as clinically indicated.

Both the MV and SB are wired, and lesions with >80% stenosis are dilated by appropriately sized balloons. Two stents are then advanced one by one, initially to the SB followed by one to the MV. After this step, both stents are pulled simultaneously back to the bifurcation to configure a Y, with the stem of the Y in the MV, completely covering the proximal end of the lesion, with one arm of the Y in the distal MV (covering the distal end of the MV lesion) and another arm in the SB (covering the distal end of SB lesions). The proximal overlapping parts of the stents are kept as short as possible but long enough to cover the proximal end of the MV lesion. Once the positions of the stents are confirmed and the proximal stent markers are overlapped, stents are deployed with simultaneous inflation at 10 to 12 atm, for 10 to 20 seconds and then deflated. This is followed by a second dilatation of the MV stent at 16 to 20 atm for 10 to 20 seconds to expand the MV stent struts fully, while the other SB stent balloon remains deflated in the SB stent. A third dilatation of the SB stent at 14 to 20 atm for 10 to 20 seconds is performed to expand the SB stent struts fully, while the other MV stent balloon remains deflated in the MV stent. This procedure is followed by the fourth and final

simultaneous inflation and deflation at 10 to 12 atm for 10 to 20 seconds to form the uniform carina of the fully expanded kissing stents. The deflated stent balloons are then withdrawn simultaneously. In cases of stent underexpansion, two high-pressure balloons of similar length (may be different sizes) are advanced for the simultaneous kissing-balloon dilatations. In the case of distal dissection, prolonged balloon dilatation is performed to avoid the need for stenting. In cases of proximal dissection, two-balloon (one in each stent) dilatation or a perfusion balloon dilatation at low pressure in the MV is performed.

During our initial experience, we compared 100 cases of SKS techniques with 100 matched cases of conventional stent technique and observed lower major adverse cardiac event and TLR rates in SKS versus conventional stent technique (18% TLR with conventional stent technique vs 5% with the SKS technique; $P=.04$) (Figure 3).⁸

Later, we analyzed our first 200 consecutive patients (202 lesions) who underwent the SKS technique for true bifurcation lesions using sirolimus-eluting stents, with a minimum follow-up of 6 months. Procedural success was 100% for MV and 99% for SB using the SKS technique, with a clinical success rate of 97%. In-hospital and 30-day major adverse cardiac events were 3% and 5%, respectively. At mean follow-up of 9 ± 2 months, the incidence of TLR was 5% in the entire group.⁹

It may be problematic to position a stent proximal to the double barrel for a residual lesion or dissection. There is an inevitable bias toward one of the two branches and the high likelihood of leaving a gap. Advancing additional stents via the double barrel sometimes may be problematic.

The Crush Technique

The crush technique was introduced at the time of DES introduction and is described here schematically. Two stents are placed in the MV and the SB, with the former more proximal than the latter. The stent of the SB is deployed, and its balloon and wire are removed. The stent subsequently deployed in the MV flattens the protruding cells of the SB stent, hence the name *crushing* or *crush technique*. The implementation of final kissing-balloon inflation was done to allow better strut contact against the ostium of the SB and therefore better drug delivery. Follow-up studies have shown that if restenosis occurs, this narrowing is very focal (<5 mm in length) and is usually not associated with symptoms or ischemia.¹⁰

Ge et al published a study to evaluate the long-term outcomes after implantation of DESs in bifurcation lesions

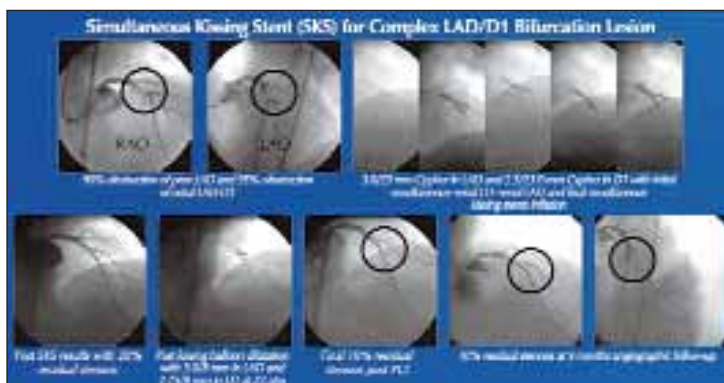


Figure 3. SKS on a complex left anterior descending/diagonal bifurcation lesion.

with the crush technique.¹¹ Although the long-term outcome of the crush stenting technique has yet to be determined, results of this study showed that compared to the absence of a kissing balloon after dilation, the crush-stenting technique with a kissing balloon after dilation appears to be associated with more favorable long-term outcomes. Therefore, when utilizing the crush-stenting technique, kissing balloon placement after dilation is mandatory to reduce the restenosis rate of the SB and the need for TLR. The main disadvantage is that the performance of the final kissing-balloon inflation makes the procedure more laborious because of the need to recross multiple struts with a wire and a balloon.

The Reverse Crush

The main indication for performing the reverse crush is to allow an opportunity for provisional SB stenting. A stent is deployed in the MV, and balloon dilatation with final kissing inflation toward the SB is performed. It is assumed that the result of the SB is suboptimal, and hence stent placement will be needed. A second stent is advanced into the SB and left in position without being deployed. A balloon, sized according to the diameter of the MV, is positioned at the level of the bifurcation, making sure to stay inside the previously deployed MV stent. The stent in the SB is retracted approximately 2 mm to 3 mm into the MV and deployed, the deploying balloon is removed, and an angiogram is obtained to verify that a good result is present at the SB (no further distal stent in the SB is needed). If this is the case, the wire from the SB is removed, and the balloon in the MV is inflated at high pressure, with final steps involving recrossing into the SB, performing SB dilatation, and final kissing-balloon inflation. The main advantages of the reverse crush technique are that the immediate patency of both branches is ensured and that the technique can be performed using a 6-F guiding catheter.

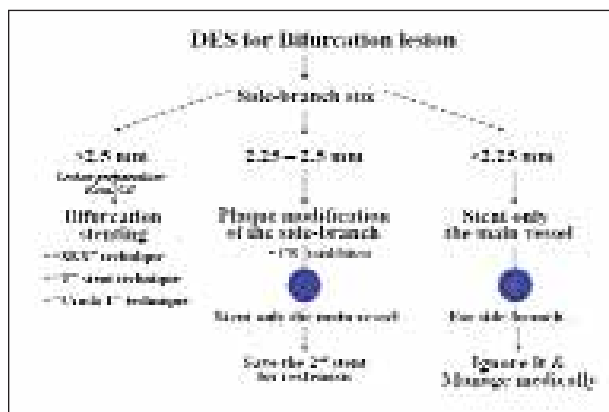


Figure 4. Algorithm for treating bifurcation coronary lesions.

T Technique

The classic T technique consists of positioning a stent first at the ostium of the SB, being careful to avoid stent protrusion into the MV. Some operators leave a balloon in the MV to help to further locate the MV. After the stent is deployed and the balloon and wire are removed from the SB, a second stent is advanced in the MV. A wire is then readvanced into the SB, and final kissing-balloon inflation is performed.

Modified T-stenting technique is a variation performed by simultaneously positioning stents at the SB and the MV.¹² The SB stent is deployed first, and after wire and balloon removal from the SB, the MV stent is then deployed. The reverse T-stenting technique is used when the SB ostium deteriorates after stent deployment in the MV, requiring recrossing the SB, dilating, and then advancing the stent in the SB. A final kissing-balloon dilatation is recommended. This technique is simple and technically less demanding. It can be used for the coverage of lesions located proximal to the bifurcation. In almost all cases, this technique will lead to incomplete coverage of the ostium of the SB.

The Culotte Technique

The culotte technique uses two stents and leads to full coverage of the bifurcation at the expense of an excess of metal covering at the proximal end. Both branches are predilated. First, a stent is deployed across the most angulated branch—usually the SB. The nonstented branch is then rewired through the struts of the stent and dilated. A second stent is advanced and expanded into the nonstented branch—usually the MV. Finally, kissing-balloon inflation is performed. This technique leads to a high concentration of metal with a double-stent layer at the carina and in the proximal part of the bifurcation. The main disadvantage of the technique is that rewiring both branches through the stent struts can be difficult and time consuming.

Y Technique

This technique involves an initial predilatation, followed by stent deployment in each branch. If the results are not adequate, a third stent may also be deployed in the MV. This technique is increasingly used with the self-expanding Dedicated DES bifurcation stent (Devax, Inc., Irvine, CA).

FUTURE DIRECTIONS AND CONCLUSION

Based on the size of the SB, an algorithm can be created in the treatment of bifurcation coronary lesions. Figure 4 is a suggested algorithm for treatment of bifurcation coronary lesions. A wire should be placed in the SB, especially if there is disease at the ostium or with a problematic takeoff. The general consensus is to try to keep the procedure safe and simple. When the SB is not severely diseased, implantation of a stent in the MV and provisional stenting in the SB are the preferred strategies.

Implantation of two stents as the initial approach is appropriate when both branches are significantly diseased and the SB is >2.75 mm in size. Final kissing-balloon inflation should be performed in these cases.

Major achievements in the stenting of bifurcation lesions since the introduction of DESs are single-digit restenosis rates on the MV and focal restenosis at the SB, which is very frequently clinically silent. ■

Samin K. Sharma, MD, FACC, is Zena & Michael A. Wiener Professor of Medicine, Director, Cardiac Catheterization Lab & Intervention, at Mount Sinai Hospital, New York, New York. He has disclosed that he receives research funding from Boston Scientific and Cordis. Dr. Sharma may be reached at (212) 241-4021; samin.sharma@mountsinai.org.

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