Systematic provisional approach to treat unselected coronary bifurcation lesions: tips and tricks

Introduction
Bifurcations account for up to 15% of all percutaneous coronary interventions (PCI) and are complex target coronary lesions in which the adoption of the most suitable treatment technique and the selection of the most appropriate coronary stent are of primary importance. A considerable volume of clinical evidence suggests that the implantation of a drug-eluting stent (DES) using a provisional approach is the gold standard for unselected bifurcated lesions.

Within the provisional approach, various degrees of intervention on the side-branch (SB) may be adopted, ranging from the simple “crossover” stenting (main vessel [MV] stenting without any intervention on the SB if flow is preserved) to the systematic kissing balloon inflation (MV stenting followed by simultaneous inflation of balloons in the MV and SB). The results of a recent trial show that kissing balloon inflation is feasible and is associated with reduced post-PCI stenosis in the SB, but does not improve the rate of major adverse coronary events. Moreover, the precise evaluation of residual stenosis of the SB in the cath lab is a matter of debate as standard two-dimensional angiography may not correctly estimate short, ostial lesions, and functional analyses show an absence of haemodynamic relevance for many angiographically significant SB stenoses. In this context, interventionalists who adopt a provisional approach have no certainty concerning how best to treat SBs after MV stenting.

At our centre, having been convinced since the introduction of DES that the provisional approach was promising for the majority of bifurcated lesions, we have gained a significant amount of experience with this approach. Thus, in this manuscript we describe the tips and tricks that are useful to know when managing coronary bifurcated lesions through a systematic provisional stenting approach.

Approach to the bifurcation (wiring and lesion preparation)
Several major randomised trials comparing one or two stents in the treatment of coronary bifurcations have shown that provisional SB stenting is quick, safe and easy to perform, and it is associated with similar results to a more complex approach.

The provisional SB stenting approach is an “A technique” (A for across the SB) within the MADS classification adopted by the European Bifurcation Club (EBC) in 2007. A 6Fr guide catheter is generally used. As a first step when performing bifurcation PCI, it is usually advisable to wire the branch, either the MV or SB with two 0.014” coronary guidewires. Details regarding the wiring techniques for complex bifurcated lesions have been recently reviewed by our group. As a general recommendation, to avoid wire twisting, we wire the more complex branch first and keep the two wires separated over the operative table by a simple sterile drape sheet (Figure 1). After wiring, the MV is pre-dilated if necessary (according to operator’s preference or after the direct stenting failure). Yet, as major MV dissection may extend toward the SB, we avoid performing systematic aggressive MV predilation. Regarding the preparation of the SB, there is general consensus that SB dilation before MV stenting should be avoided in the majority...
of cases as balloon dilation may cause SB dissections that may present an obstacle during the rewiring phase. Accordingly, we recommend only predilating the SB if the risk of SB occlusion is high (tight ostial stenosis) or if there is deemed to be a high likelihood of needing to implant a second stent (diffuse disease), especially when dealing with large, important SBs with unfavourable take-off angles.13,14

Main Vessel stenting
After wiring both branches and eventual predilation, the stent is deployed in the mV across the ostium of the SB. Firstly, it should be emphasised that operators systematically adopting a provisional approach should carefully consider the operative mV axis. Indeed, when treating a bifurcated lesion with a single stent, it is crucial to cover as much of the atherosclerotic disease as possible with the stent. This means that, in the case of left main disease extending toward the circumflex, a non-diseased left anterior descending artery may be considered an SB and, consequently, the stent can be implanted from the left main to the circumflex. Other important factors that may increase the safety of a provisional approach when selecting the “operative” mV axis are: (1) the evaluation of the likely difficulty in rewiring – in the case of prohibitive take-off, it is advisable to implant the stent from the mV toward the angled vessel – and (2) the evaluation of the vessel sizes – it is advisable to implant the stent from the mV toward the larger vessel. Such behaviour, in our experience, is associated with smooth provisional procedures and may reduce the need for a SB stent.

While performing a provisional approach, it also should be recognised that the mV stent selection is of crucial importance to guaranteeing an acceptable final result. Since previous pathological studies and in vivo intravascular ultrasound (IVUS) and optical coherence tomography (OCT) evaluations demonstrate that atherosclerosis occurs predominantly at the lateral walls of the bifurcation, while carina (flow divider) involvement in atherosclerosis is unusual, mV stenting may mainly cause carina shift, rather than a plaque shift.15,16 As a consequence, mV stent oversizing in the critical area of the carina (i.e. the segment of mV located immediately after the SB take off) should be avoided, especially when dealing with bifurcations with acute angles. Thus, the mV stent diameter should be selected on the basis of the distal mV segment diameter. This may cause suboptimal stent deployment in the proximal MV, which should be corrected by post-dilatation of the proximal part of MV with appropriately sized balloons.
Careful attention is also required when selecting the length of the mV stent. Indeed, as the need for proximal MV stent post-dilatation and kissing balloon inflation can be anticipated, it is important to cover at least 8–10 mm of the proximal segment of the MV. This should avoid balloon injuries to uncovered parts of the MV in the following phases of the provisional approach.

Finally, the impact of different stent designs on SB patency and access should be considered. Available DESs differ considerably in design, and these differences may influence coverage of bifurcated lesions. In keeping with this hypothesis, MV stenting with different DESs has been associated with different rates of flow impairment in (small) SBs after MV stenting (Endeavor vs. Taxus). DES platforms are also associated with different behaviour when the SB is dilated,17 and the ability to dilate the lateral cells is highly variable.17,18 Thus, stent cell circumferences should ideally match the ostium circumferences of the SBs that are going to be treated. Finally, important differences in stent deformation and polymer integrity have recently been found across different DES thus suggesting that DES selection may be crucial in bifurcation PCI according to the provisional approach.19

Proximal Optimisation Technique (POT)
As previously discussed, the selection of MV stent diameter on the basis of distal MV circumference can lead to malaposition of the stent in the proximal MV segment. Such a drawback may be corrected by post-dilatation of the stent proximal to the carina, using a balloon sizing that matches that of the proximal MV. This technique has been called “Proximal Optimisation Technique” (POT)1 and it can be considered an essential step for the routine provisional approach, as it should ensure appropriate apposition of the stent in the proximal MV, as well as enhanced protrusion of the MV stent struts into the SB ostium space.

The balloon used for POT should be short enough so as not to exceed the proximal edge of the stent nor reach the distal MV (in order to avoid carina shift). Regarding the type of POT balloon, although the use of non-compliant balloons has been described, we generally select either semi-compliant or non-compliant balloons depending on the specific setting. Balloon
compliance may allow for better adjustment of the balloon to artery size in the absence of intravascular imaging evaluation. Non-compliant balloons are favoured when MV stent under-expansion is suspected, while semi-compliant balloons are favoured in the remaining cases.

**Side Branch rewiring after main vessel stent implantation**

After MV stenting, a variety of situations exist, ranging from those in which a SB with favourable take-off is perfectly patent to those in which a SB with difficult take-off has completely disappeared. In recent years, it has been recognised that the SB rewiring site may influence the type of MV stent distortion after SB dilation, as crossing of the distal side cells of the MV stent is associated with better ostium scaffolding and reduced need for SB stenting. Accordingly, regardless of the selection of the type and shape of the guidewire, the operators should focus their attention not only on getting into the SB through the stent, but also on doing this in the very distal part of the SB ostium.

**fig. 2**
The “pullback” rewiring technique

*Images are obtained in a silicon bench testing model of bifurcation using Cypher (Cordis, Johnson & Johnson) stent and BMW universal (Abbott Vascular) guidewires. A stent is deployed in MV, after wiring of guidewire in MV and SB; B and C rewiring of SB using the “pullback” technique from the distal MV; D kissing balloon inflation; E and F if the SB needs to be stented, a second stent is positioned in the SB with an uninflated balloon in the MV; G the stent is deployed in the SB slightly protruding into the MV; H the balloon of the SB is retrieved and aligned with the MV balloon to perform the final kissing balloon; I final result of TAP stenting.*
To this aim, it is now commonly accepted that the best way to wire the SB is by using a “pullback” rewiring technique (Figure 2). With this technique, it should be emphasised that it is important to obtain a sufficiently wide curve to allow the wire to scrape the MV stent struts. This will lead to immediate protrusion of the wire into the SB as soon as it is reached by the pullback. A common pitfall associated with rewiring failure results from the presence of an under-expanded stent in the MV preventing the wire from reaching the (compromised) SB ostium. Accordingly, proximal MV stent post-dilatation with the “POT” technique is highly advisable in any case in which there are rewiring issues. Support in favour of POT as a method of facilitating rewiring comes from bench tests showing protrusion of the MV stent struts into the SB ostium space and from computer simulations showing the modification of the stent’s side cells shape with increasing balloon size.

**Kissing balloon inflation**

Different criteria have been used to define an acceptable result in the SB following MV stenting. There is still, however, significant debate regarding the routine use of kissing inflations. In general, it is advised that, in the absence of flow impairment and/or an angiographically tight lesion at the ostium of the SB, kissing balloon inflation should not be required routinely. However, when a tight lesion (>75%) is present in the SB after MV stenting, it is known that a kissing balloon inflation will reduce its functional significance.

Kissing balloon inflation expands and scaffolds the SB ostium and facilitates future access to the SB. The choice of balloons for kissing inflation should be determined by selecting diameters that match the two branches and lengths that are sufficiently short enough to avoid inflating out of the stent. A table with the theoretical dimensions obtained by the overlapping balloons in the MV, according to the combination of different balloon sizes, has been derived from bench test and mathematical models. Short kissing balloons are favoured; bench testing has demonstrated increased MV stent “distortion” when there is a long overlap between the two balloons in the proximal MV. Finally, a recent suggestion by some operators has been to use non-compliant balloons to improve stent expansion and reduce of SB dissection risk.

We usually perform kissing balloon inflation by connecting both balloons to a single indeflator using a triple way stopcock and a double male connector (Figure 3). This allows a single operator to efficiently perform simultaneous inflation and deflation of kissing balloons.

**Side Branch stenting**

In cases of unsatisfactory results after kissing balloon inflation on the SB (>75% residual stenosis, dissection, thrombolysis in myocardial infarction [TIMI] flow Grade <3), especially in relevant SBs, the possibility of stenting the SB should be considered. In such conditions, four techniques for SB stenting can be considered: T-stenting, TaP stenting, Culotte or a reverse/internal crush. In our centre, when the need arises, we usually implant the SB stent according to the TaP technique, as it is basically an evolution of T-stenting and provides ostial coverage following final kissing balloon inflation.

Obviously, the operator performing the TAP technique should try to limit, as much as possible, the length of protrusion into the MV (Figure 2).

**Technical key-points to increase safety and efficacy of the provisional approach**

In cases of flow compromise of an important SB and failure after multiple rewiring attempts, a ‘rescue’ jailed balloon technique can be applied by using the wire in the SB to advance a small balloon at the SB ostium under the MV stent. Indeed, once the balloon has successfully entered the SB ostium under the MV stent struts, it may be inflated to re-open the SB. The re-establishment of SB flow may facilitate rewiring and then correction of MV stent
to try to restore SB flow. SB rewiring and kissing modifier to facilitate rewiring or can be dilated balloon is removed uninflated. If SBs become as a result of its SB ostium spatial occupation. If protection is based on the placement of a balloon balloon, which remains under the stent struts, serves to reduce both carina and plaque shifts as a result of its SB ostium spatial occupation. If SB flow is preserved after mV stenting, the jailed balloon, which remains under the stent struts, serves to reduce both carina and plaque shifts as a result of its SB ostium spatial occupation. If SBs become occluded after mV stenting, the jailed balloon may either be used as a marker and a favourable angle modifier to facilitate rewiring or can be diluted to try to restore SB flow. SB rewiring and kissing balloon inflation must be performed to correct stent deformation or malposition.

Finally, novel stent platforms designed for bifurcated lesions should be mentioned. Indeed, among the various possible designs (and underlining theoretical concepts), a subgroup of stent platforms has been developed with the aim of facilitating the provisional approach. In general, this class of bifurcation-dedicated devices offer improved SB scaffolding after mV stent implantation and some of them also avoid the need for rewiring. Clinical studies will, in the future, provide answers regarding their role and impact on patients’ clinical outcome.

Conclusions

Provisional SB stenting is associated with excellent short- and mid-term results and remains the gold standard for most bifurcations. However, it is important to optimise the performance of this technique by following the series of simple but important steps described in this article. Doing so will likely improve outcomes in unselected coronary bifurcation lesions.

REFERENCES


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