CHAPTER 7

Left Main Interventions

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Introduction

Left main (LM) stenting is an acceptable alternative to coronary artery bypass grafting (CABG) in patients with low and intermediate SYNTAX score.[1] Indications for LM stenting are: a) LM lesion diameter stenosis >70% by angiography; b) Minimal luminal area (MLA) < 6.0 mm2 by IVUS or OCT; or c) Fractional Flow Reserve (FFR) < 0.80. [1] This can be classified into 2 categories based on disease location: I) Ostial and shaft LM II) True left main bifurcation (LMB) (accounted for 81 % of LM stenoses).

Medina classification for LM bifurcation

The Medina classification is an angiographic classification of bifurcation lesion distribution that assists in defining plaque distribution and procedural planning but does not predict outcomes of PCI. Stenosis in the LM, origin of the left anterior descending artery (LAD) and the origin of the left circumflex (LCX) are each assigned a number (0 for no disease and 1 for the presence of disease). Medina class 1.1.1, 1.0.1, and 0.1.1 are true bifurcation lesions (**Figure 1**).[2-4]

Key principles of LM stenting include:[5]

1. Protection of the side branch (LCX) with a second guide wire.
2. Proximal optimization technique (POT) to optimize the stent in the LM and facilitate side branch crossing.

3. Intravascular imaging with either intravascular ultrasound (IVUS) or optical coherent tomography (OCT) with a target of mean stent area (MSA) > 10.5 mm2 in the LM.

Proximal optimization technique (POT)

POT provides the LM crossover stent two distinct diameters corresponding to the diameters of of the two covered segments (LAD and LM) that were derived by Murray's law (73). This technique allows for the reconstruction of the initial physiologic anatomy of the bifurcation and follows the fractal law of Finet (**Figure 1B**).

POT facilitates wire exchange, particularly when SB treatment or rescue is needed, by avoiding luminal wire exchange outside the proximal part of the stent (75). The LM stent should be implanted sufficiently proximal to the SB to accommodate a short, large diameter balloon sized to the LM and at least 6 or 8 mm in length. The distal marker of this balloon must be positioned in front of the carina (**Figure 2**).

Optimization of the proximal stent segment allows strut protrusion into the SB with a larger strut opening, as well as limiting if not eliminating carinal shifting for easier guidewire exchange. POT also permits optimization of the stent diameter to the LM diameter, correction of malapposition, and reduction in ellipticity of the stented segment (70).

Consideration of Left ventricular (LV) support

LV support is not routinely needed for stable patients with unprotected LM disease and preserved LV function. Indications for LV support include unprotected LM disease with: 1. LV ejection fraction < 35%; 2. Anterior wall myocardial infarction; 3. Concomitant occlusion of a dominant right coronary artery; 4. Coronary atherectomy with low EF.

Access

Both transfemoral and transradial access (TRA) can be used. For TRA, the guide catheter should be a 6 French size or larger.

Guiding Catheters

To avoid guide catheter trauma from a deep intubation of the LM and to allow for guide catheter pullback for ostial LM inflation, a JL 3.5 or 4.0 catheter may be considered.

Stent selection

Drug-eluting stent is currently a standard practice. Stent selection is a crucial step in LM stenting to avoid an undersized stent and overexpansion of the LM stent. The current available large diameter coronary stents in the US and maximum overexpansion diameter are showed in **Table 2**.

Step-by-Step techniques

I) PCI to ostial and shaft LM

Target lesion revascularization (TLR) rates are extremely low at 4.5 % with ostial and shaft LM stenting.

1. Predilatation with a non-compliant balloon or atherectomy may be required in a calcified lesion. A 1.5 mm or 1.75 mm rotational atherectomy burr may be required for short runs not exceeding 10-15 seconds (1.25 mm sized burr less favorable due to risk of burr stuck). Post RA, a non-compliant balloon sized to the LM should be inflated to assure full expansion and resolution of any ‘waist’.

2. Imaging for stent sizing is ideal. Short 8-9 mm stents are prone to slippage and geographical miss. Ideally, there should be adequate length of the LM to accommodate a stent 12 mm in length.

3. The stent should be positioned with minimal 1-2 mm protrusion into the aorta. Stent positioning should be checked in multiple views such as left anterior oblique (LAO) caudal or 'Spider' view and LAO cranial views with small puffs of contrast. A second wire positioned in the cusp may serve as a 'marker' with the crossing point of the coronary guide and cusp wire indicating the site of the LM ostium (**Figure 3**).

4. Following stent deployment, the stent balloon should be withdrawn halfway out into the cusp. The balloon is then inflated and with forward pressure on the guide gently tugged up and down to optimize ostial coverage.

5. Final intravascular imaging should be performed.

II) PCI to left main bifurcation (LMB)

Interventions to LMB occur in 81 % of cases. TLR rates are < 14% and occur mostly at the left circumflex ostium. Hence, the driver for deciding the stenting strategy is preservation of the side branch (SB), generally the left circumflex artery. It may be useful to classify the LMB into the "simple" and "complex" lesions. Stenting strategies can then be approached by the left main bifurcation algorithm (**Figure 4**).

Through clinical trials, four techniques have evolved that require familiarity and proficiency by the practicing interventionalists:

1. Provisional stent (PS) technique for simple lesions. This strategy is used in approximately 75 % of cases (**Figure 5**).

2. T and minimal protrusion (TAP) technique (**Figure 6**).

3. Culotte technique (**Figure 7**).

4. Double kiss crush (DK crush) for the complex LM lesion

Controversy: Kissing balloon inflations (KBI) in Provisional stenting (PS)

Kissing balloon inflation describes the technique of inflating balloons simultaneously in both the LM and the SB. However, routine KBI in the MB and SB after PS has failed to provide clear clinical benefits.[6,-11] During a two-year follow-up, the rate of the composite of death, MI, or TLR was not significantly different between KBI or no KBI, regardless of angiographic SB stenosis (12.5% in the final kissing balloon (FKB) group and 8.5% in the non-FKB group). Five year follow up of the DK CRUSH II study demonstrated that in the PS group, TLR with FKB was 19.4 % vs 5.2 % without FKB (P=0.31).[12]

Double kissing (DK) crush stenting

This strategy is used for the complex lesion with significant stenosis of the LCX side branch. Double kissing (DK) crush stenting technique is a modification of the classic crush technique.[13] Following the results of DK crush V study comparing DK crush stenting vs PS (1-year target lesion failure of 4.8 % vs 18 %), a two stent DK crush technique is the procedure of choice for the complex LM bifurcation lesion.[14] This is shown in **Figure 8**.

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Tables

Table 1: Current left main revascularization guidelines

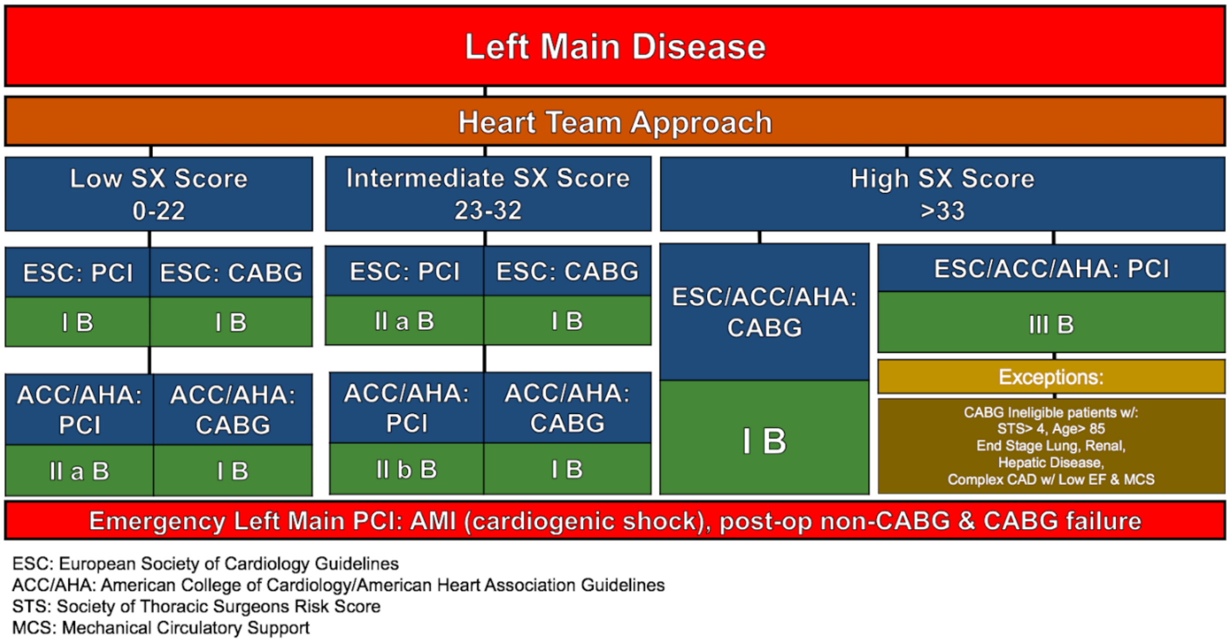
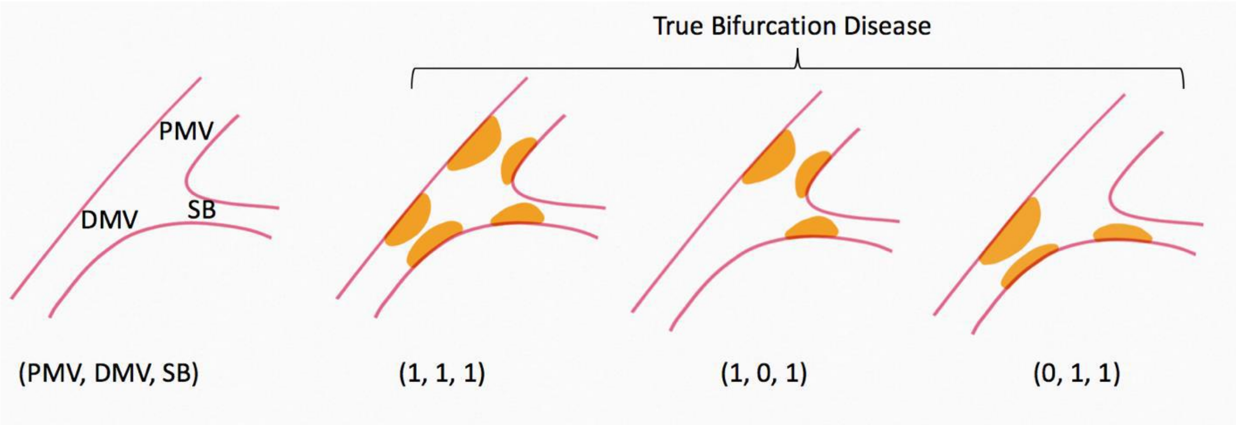


Table 2: Currently large diameter coronary stents for left main intervention

Stent Type	Synergy	Resolute Integrity	Onyx	Onyx XL	Xience Alpine	Orsiro	Ultimaster	Biomatrix
Device Company	Boston Scientific	Medtronic	Medtronic	Medtronic	Abbott	Biotronik	Terumo	Biosensors
Largest size (mm)	4.0	4.0	4.0	4.5 -5.0	4.0	4.0	4.0	4.0
Crowns	10	9.5	9.5	10.5	9	6	8	9
Point Connectors	2-5	3	2.5	2.5	3	3	2	3
Cell opening for side branch access (mm)	1.09	1.03	1.03	1.03	1.11	1.04	0.99	1.37
Maximum expansion(mm) Manufacturer recommended	5.7	4.75	4.75	5.75	4.6	4.4	4.57	5.8
Maximum expansion (mm) Bench testing	5.7	5.4	5.5	5.9	5.6	5.2	5.8	5.8

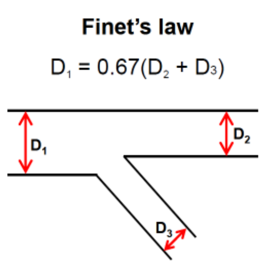
Figures

Figure 1: True left main bifurcation based on Medina Classification



PMV; proximal main vessel, SMV; distal main vessel, SB; side branch.

Figure 1B: Finet's Law



LM final stent diameter or D1 = (Diameter of LAD or D2+ Diameter of LCX or D3) X 0.67

Figure 2: Proximal optimization technique (POT)

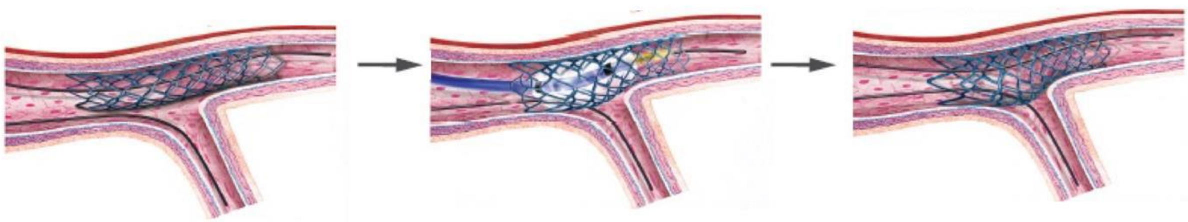


Figure 3: Stent positioning at ostial left main by using “Marker Wire” technique

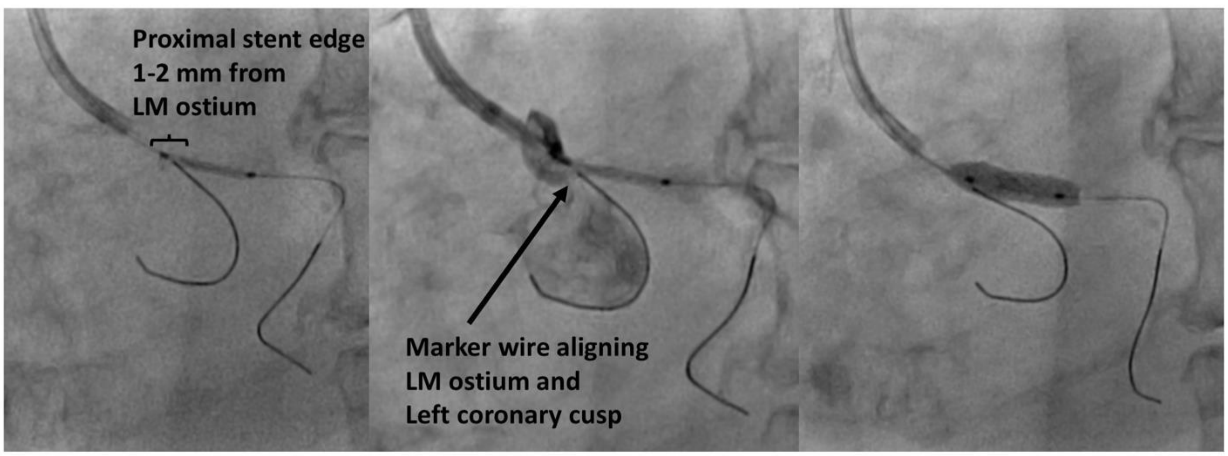


Figure 4: Algorithm for left main bifurcation intervention

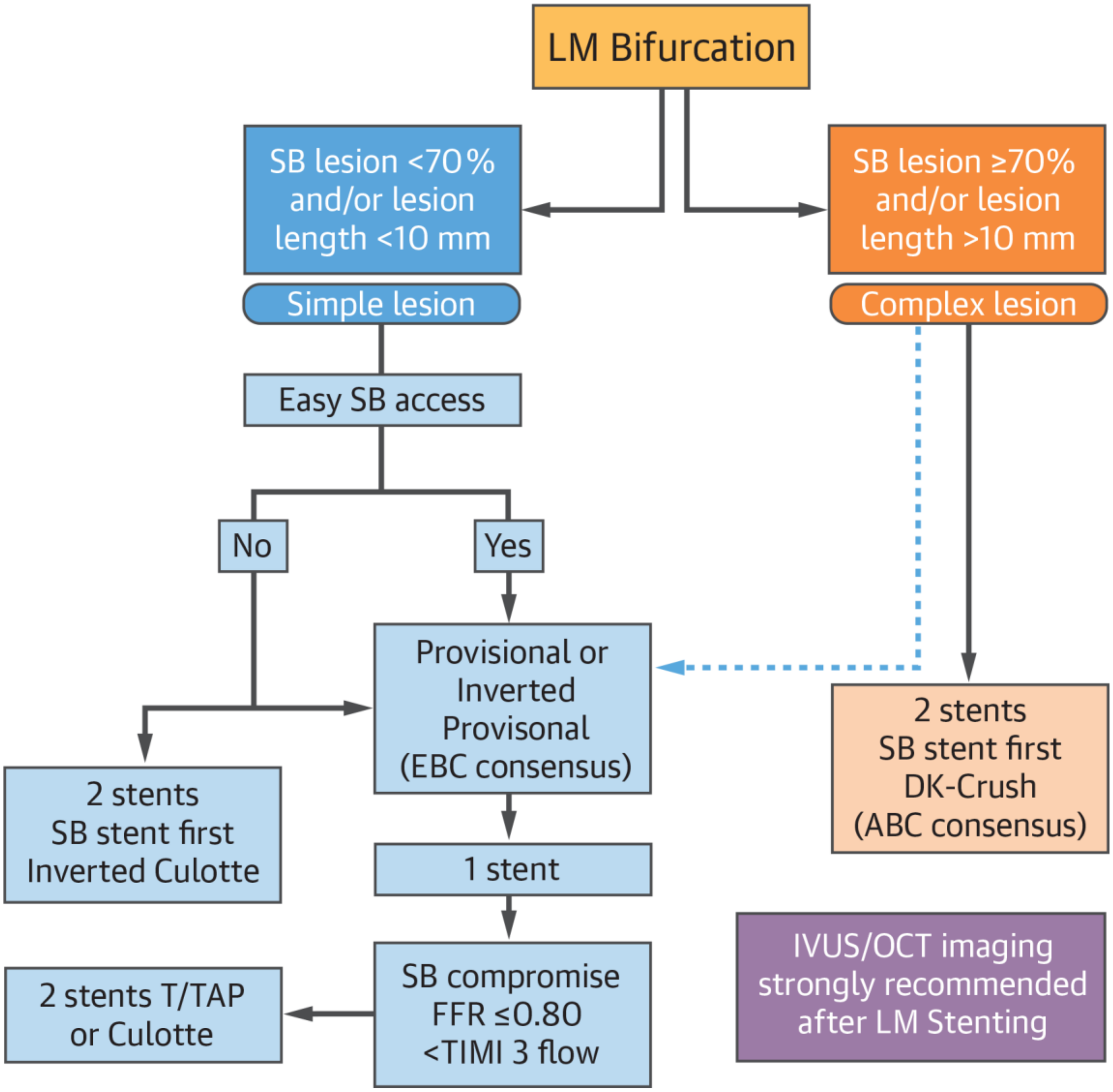


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Figure 5: Steps in a single stent crossover (provisional stent) technique for the simple lesion

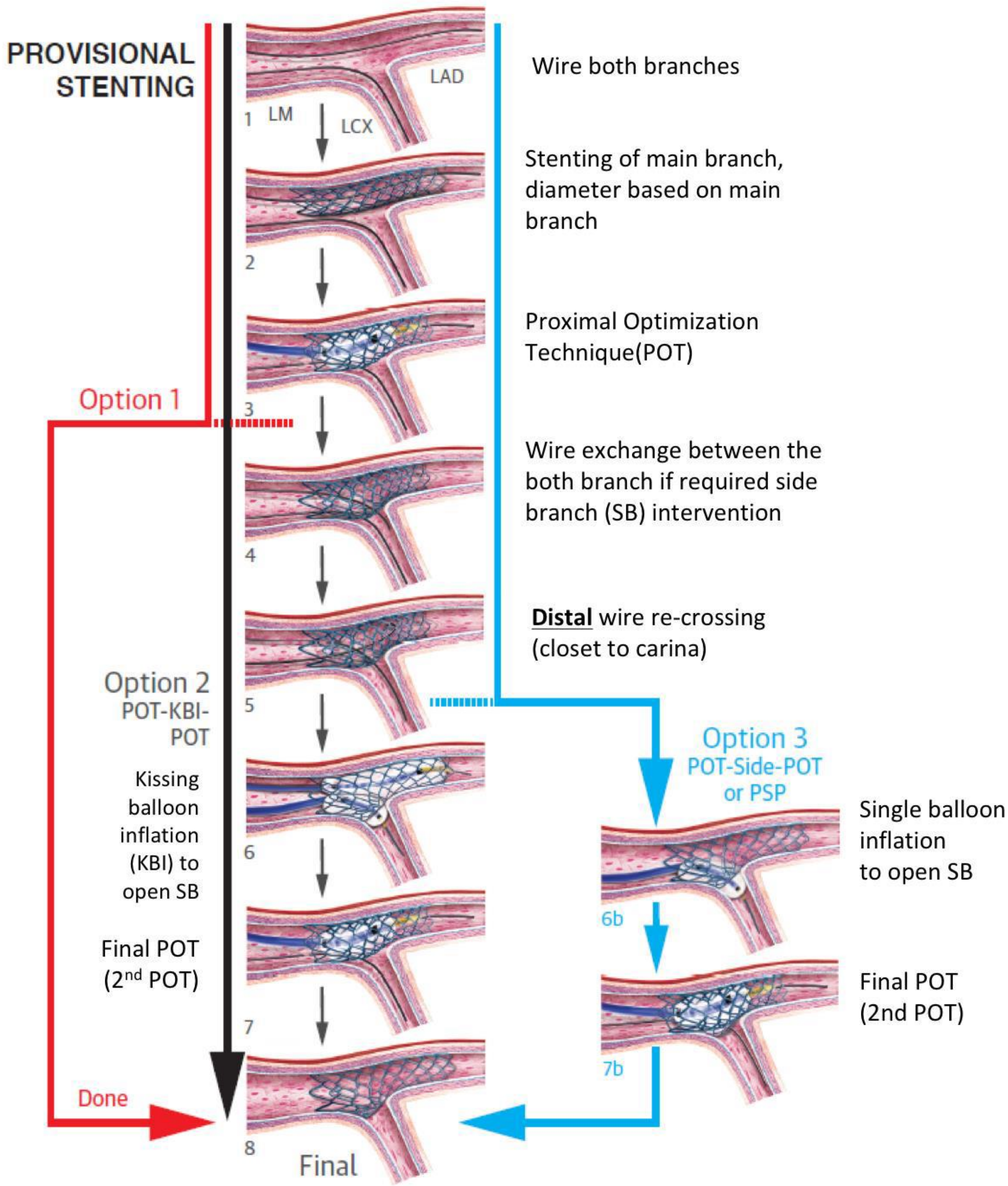

Figure 6: Steps in T-and-Minimal Protrusion (TAP) technique

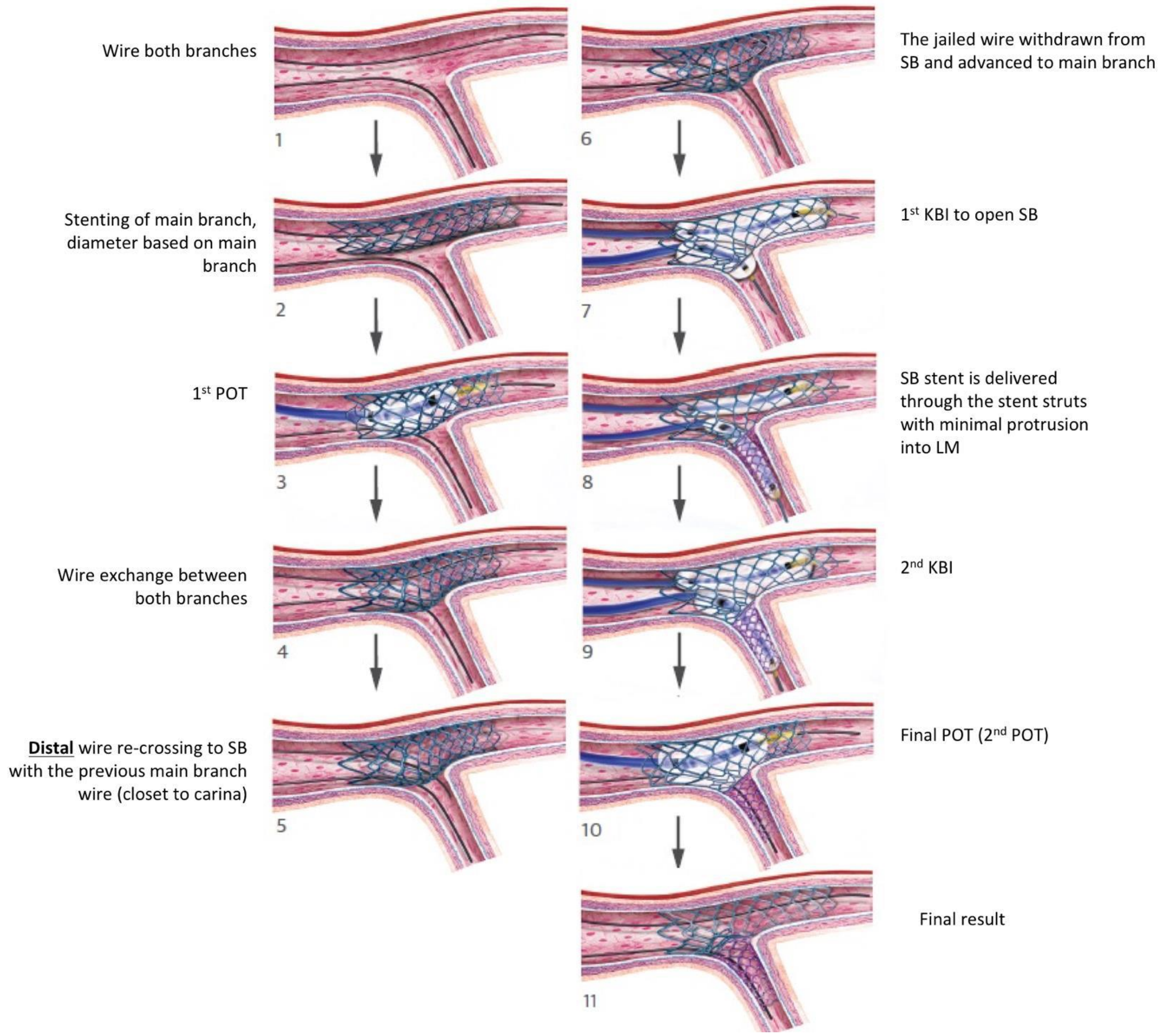

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Figure 7: Steps in Culotte technique

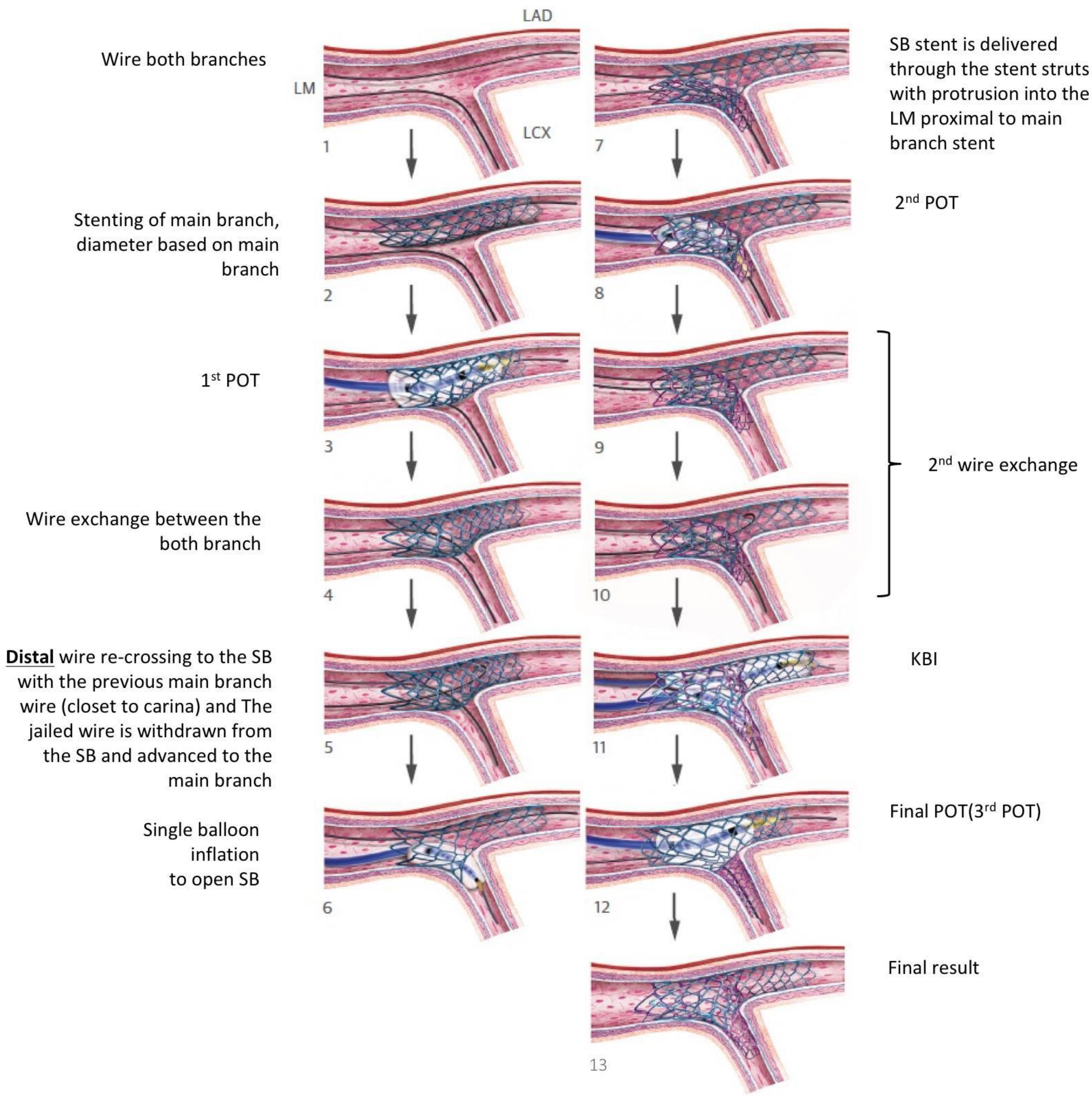

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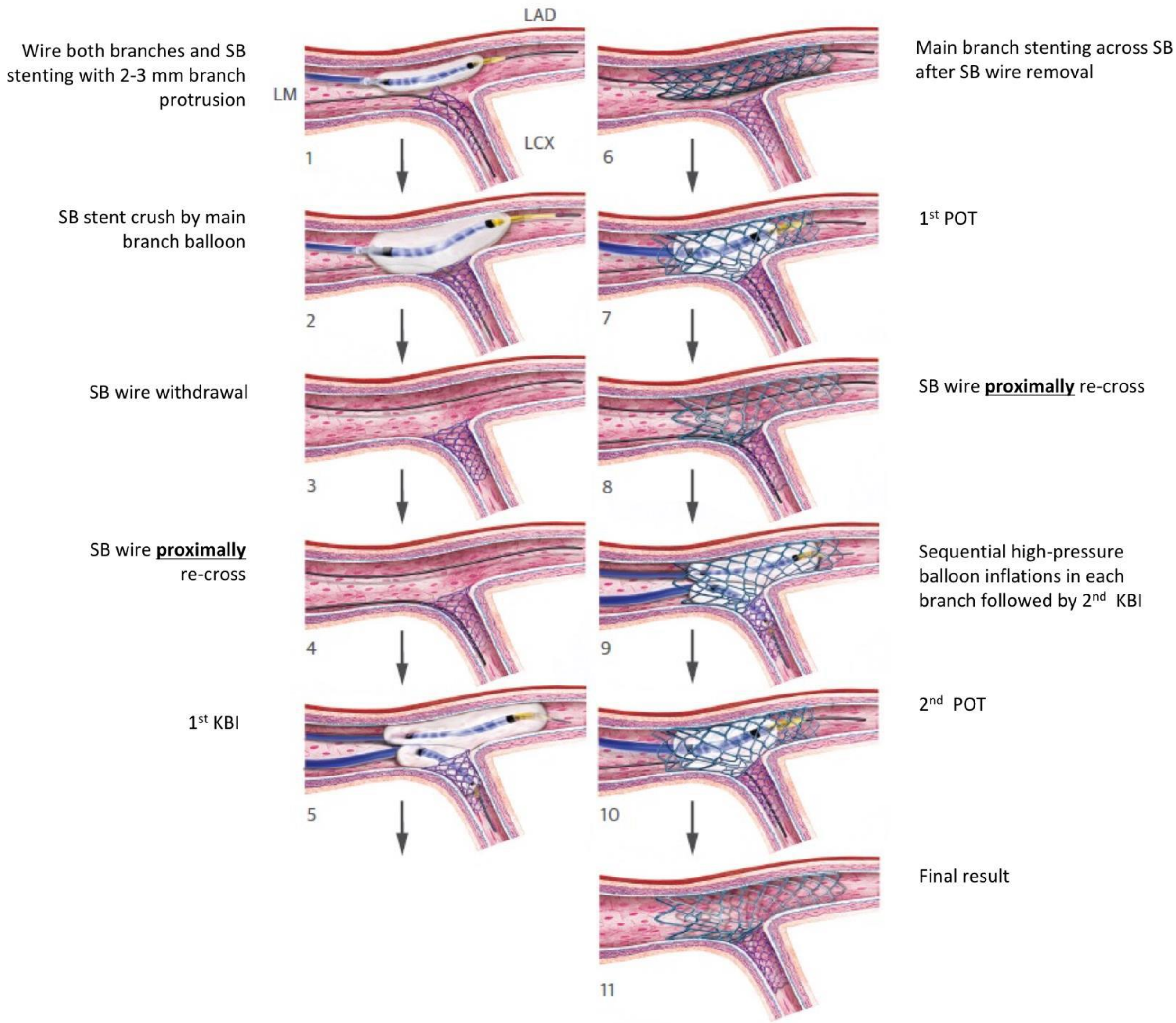
Figure 8: Steps in Double Kissing (DK) Crush technique



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