Understating Coronary Bifurcation Intervention

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Bifurcation Coronary Disease

- **15~20% of PCI patients**
- **DES enhanced success rate, but have not resolved completely**
- **Dependable strategy – not established**

  - Rare studies evaluating anatomical intricacies

  - Lack of large randomized trials

  - Many anatomical variants

    → Single technique can't fit all

Difficulties of Bifurcation PCI

- **Risk of periprocedural complication**
- **Relatively high restenosis**
- **Not all lesions are the same**
  - Size of vessels (Meaningful SB size ≥2.25mm)
  - Variable plaque distribution
  - Extent of SB disease
  - Variable angulation
- **Higher risk of stent thrombosis**

→ PCI techniques are mainly based on personal experiences from skilled operators

Factors to be considered for PCI strategy

- **Anatomical factors**
  - LMCA bifurcation
  - Location of plaque (Anatomical classification)
  - Plaque or carina shift
  - Angle btw SB and MB
  - Dynamic change in bifurcation anatomy
- **Modalities for objective anatomical evaluation**
  - QCA, IVUS, FFR
- **Selection of devices and strategies**
  - DES vs. BMS
  - Single vs. Double stent techniques
  - Kissing balloon or not
  - Dedicated bifurcation stents

Classification of Bifurcation Lesions

- Plaque Location

- Plaque Extent

- Angle

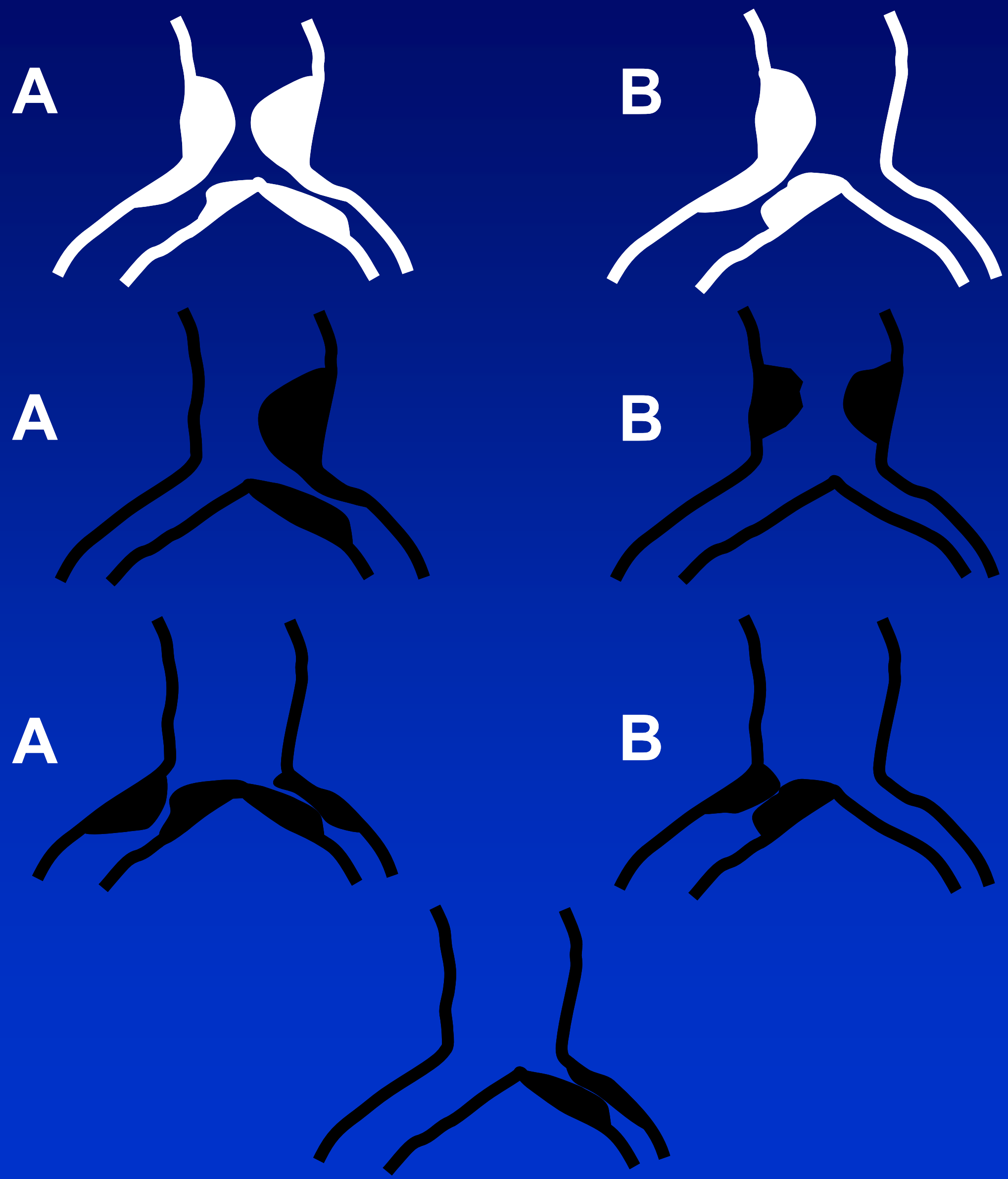
Safian Classification

Type I
Parent vessel stenosis proximal and distal to bifurcation

Type II
Parent vessel stenosis proximal to bifurcation

Type III
Parent vessel stenosis distal to bifurcation

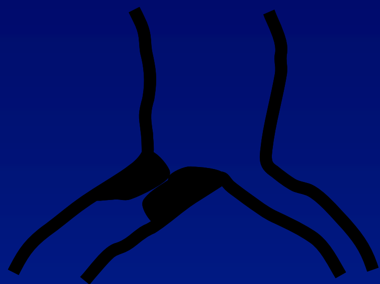
Type IV
Parent vessel normal, ostial side branch stenosis



Duke Classification

Type A

Prebranch stenosis not involving the ostium of the side branch



Type B

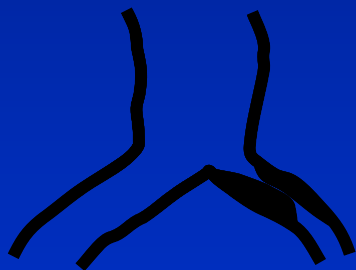
Postbranch stenosis of the parent vessel not involving the ostium of the side branch

Type C

Stenosis of the parent vessel not involving the ostium of the side branch

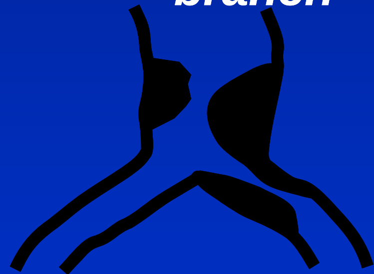
Type D

Stenosis involving the parent vessel and the ostium of the side branch



Type E

Stenosis involving the ostium of the side branch only



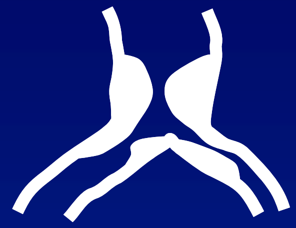
Type F

Stenosis discretely involving the parent vessel and ostium of the side branch

Lefevre (ICPS) Classification

Type 1

Lesions located in the main branch, proximal and distal, and the ostium of side branch



Type 2

Lesions located only in the main branch, proximal and distal, and not the ostium of side branch

Type 3

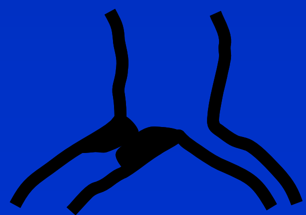
Lesions located in the main branch proximal to the bifurcation

Type 4

Only the ostium of each branch of the bifurcation involved with no proximal disease

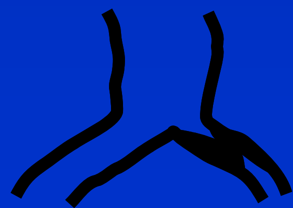
Type 4a

Lesion located only in the ostium of main branch

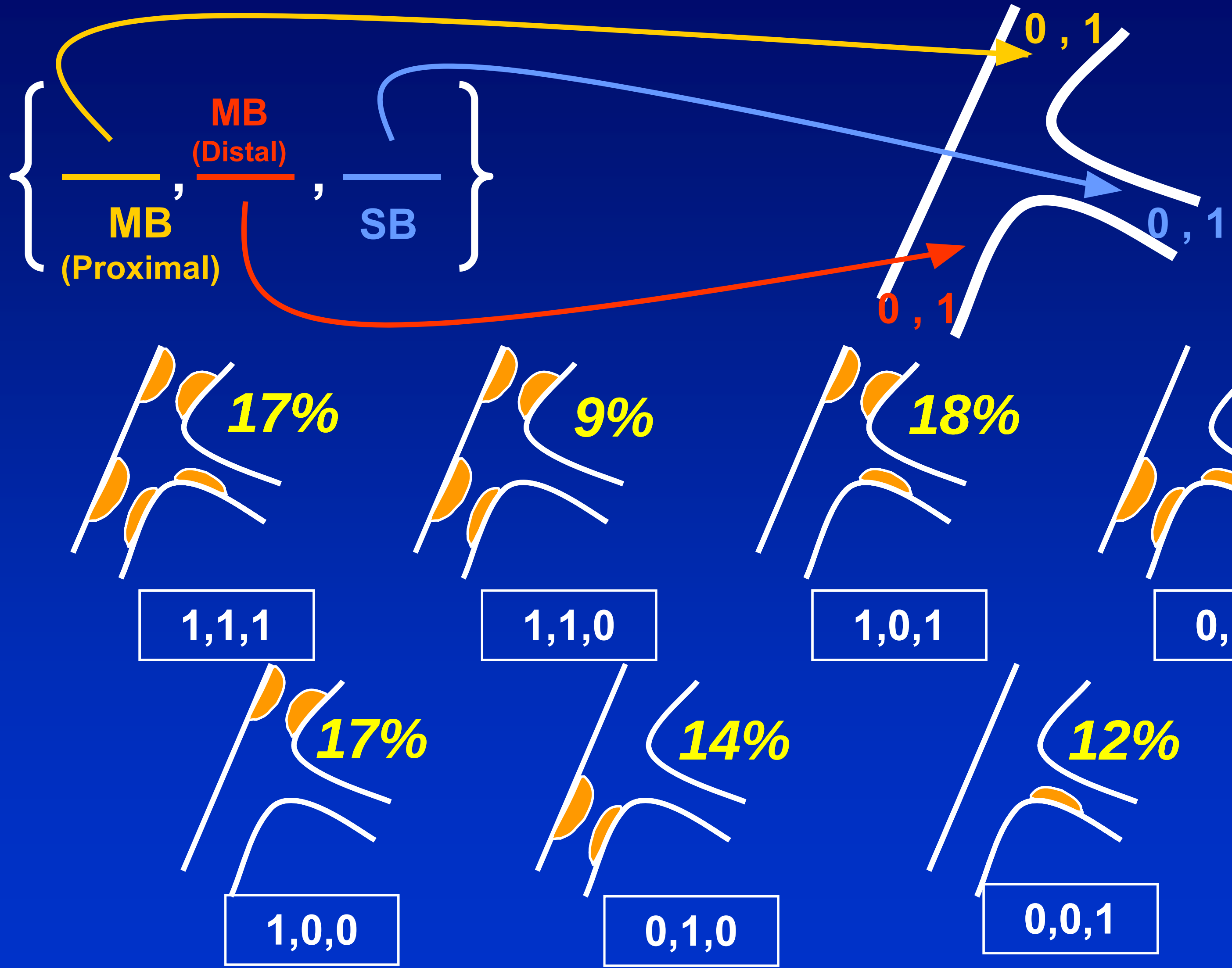


Type 4b

Lesion located only in the ostium of side branch



Medina Classification



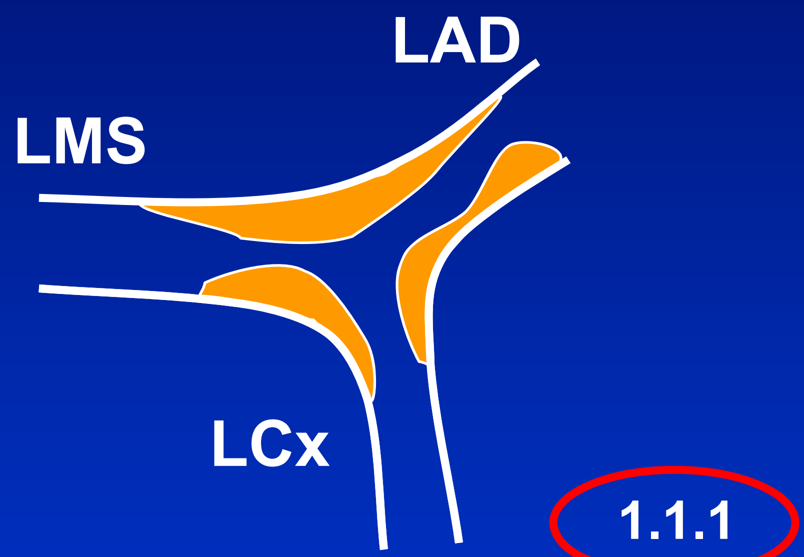
Limitations of the Medina classification

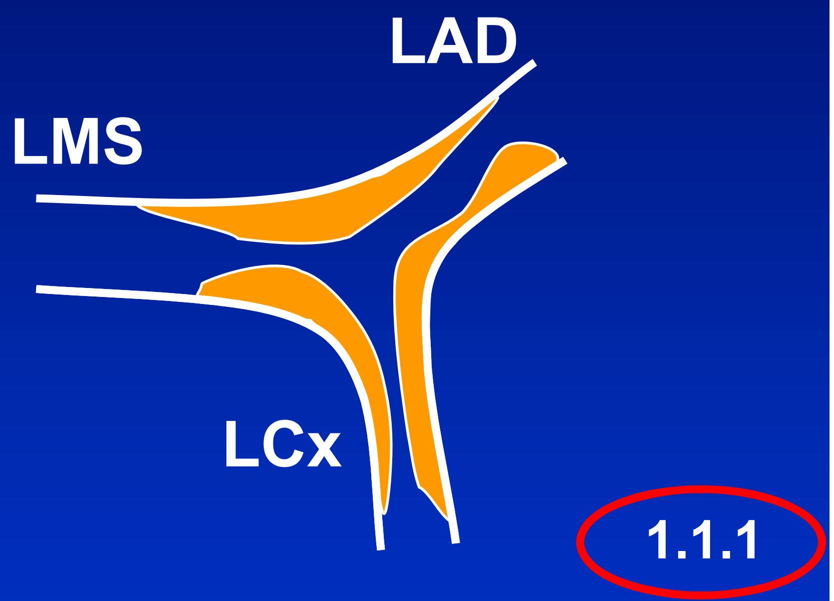
- Does not take into account
  1. Length of disease in the ostium of the SB

More precise classification system?

  3. Trifurcation
  4. Vessel angulation
- The LMCA differs from many other bifurcation lesions due to the importance of the SB (LCx)

Plaque Burden at the SB Ostium

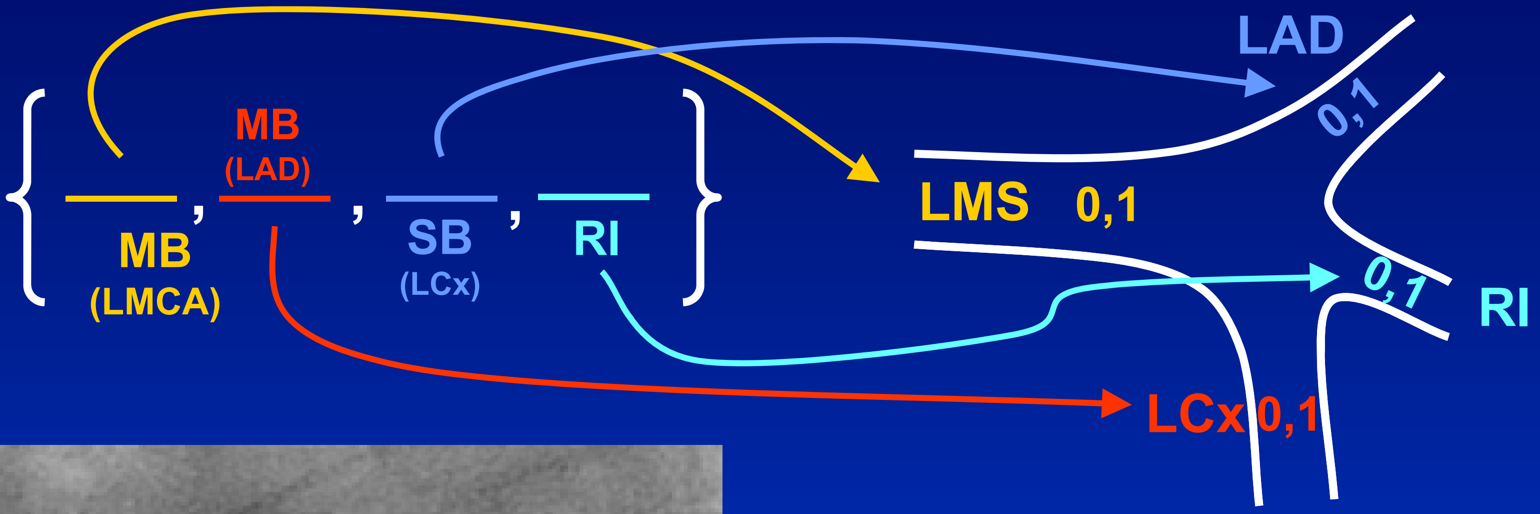


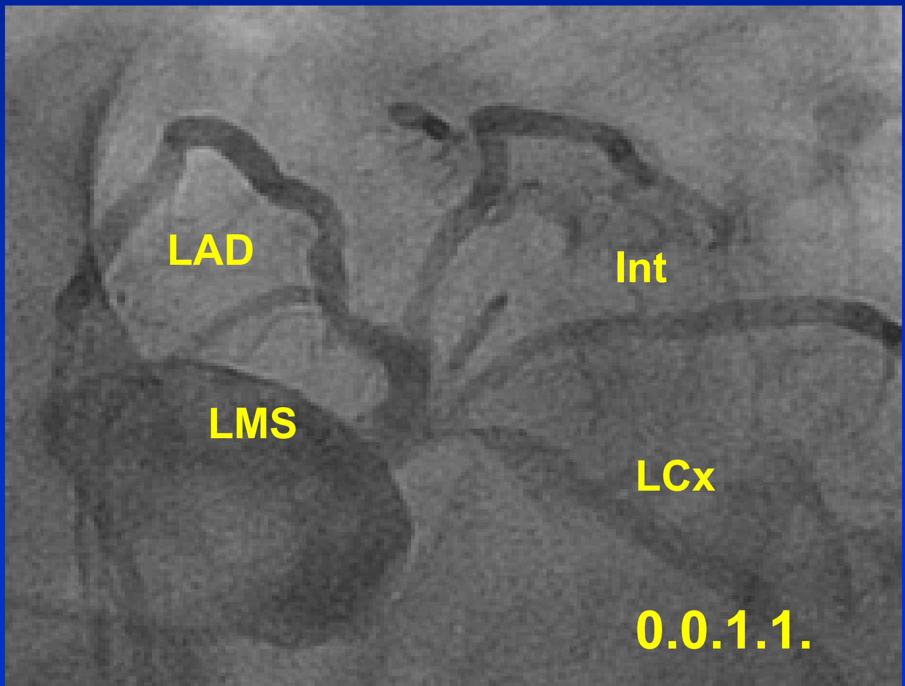


Provisional strategy better

Two stent strategy better

Trifurcation



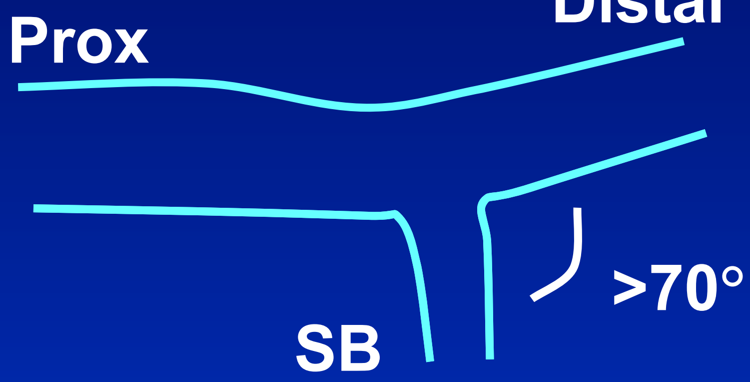


- **If, RI size > LCx**

  → LM, LAD, RI, LCx

Angulation

T-shape

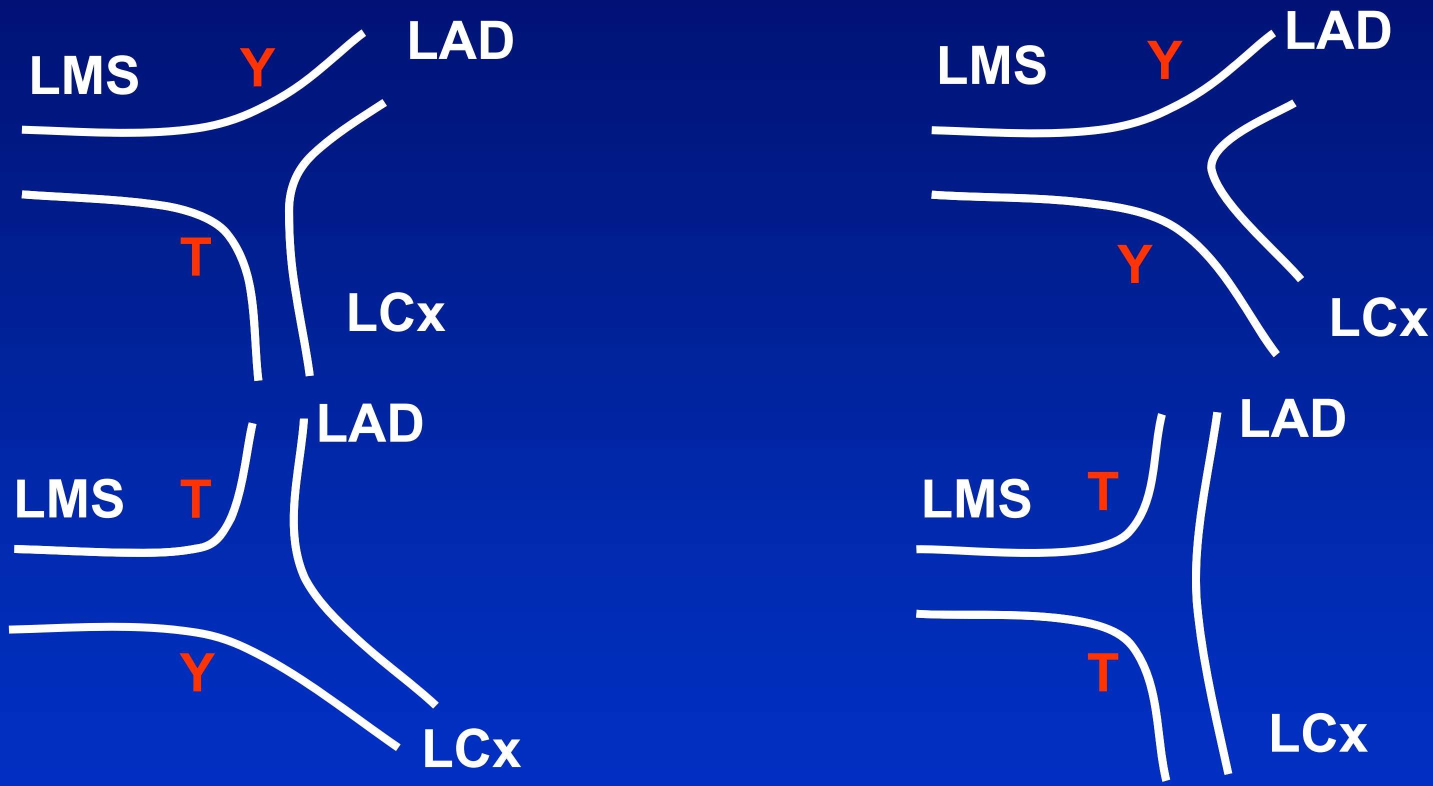


Y-shape

- Difficult SB access
- Less plaque shifting
- T-stenting better

- Easier SB access
- More plaque shifting
- Cullotte or Crush better

Angulation



- **Should this be taken into account in the classification?**

However ……

- Any classification must be simple to apply and to remember!
- Inclusion of too many variables will make the system too complex to apply in practice

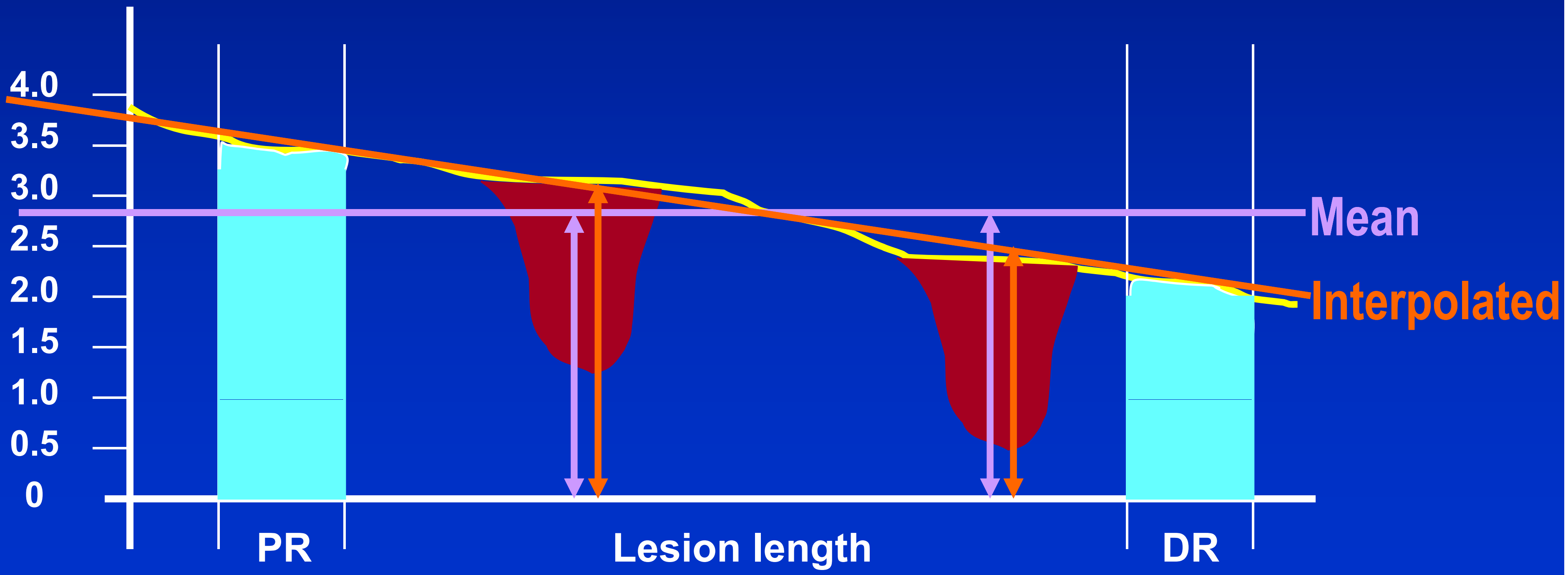
QCA of

Bifurcation Lesions

Interpolated Reference

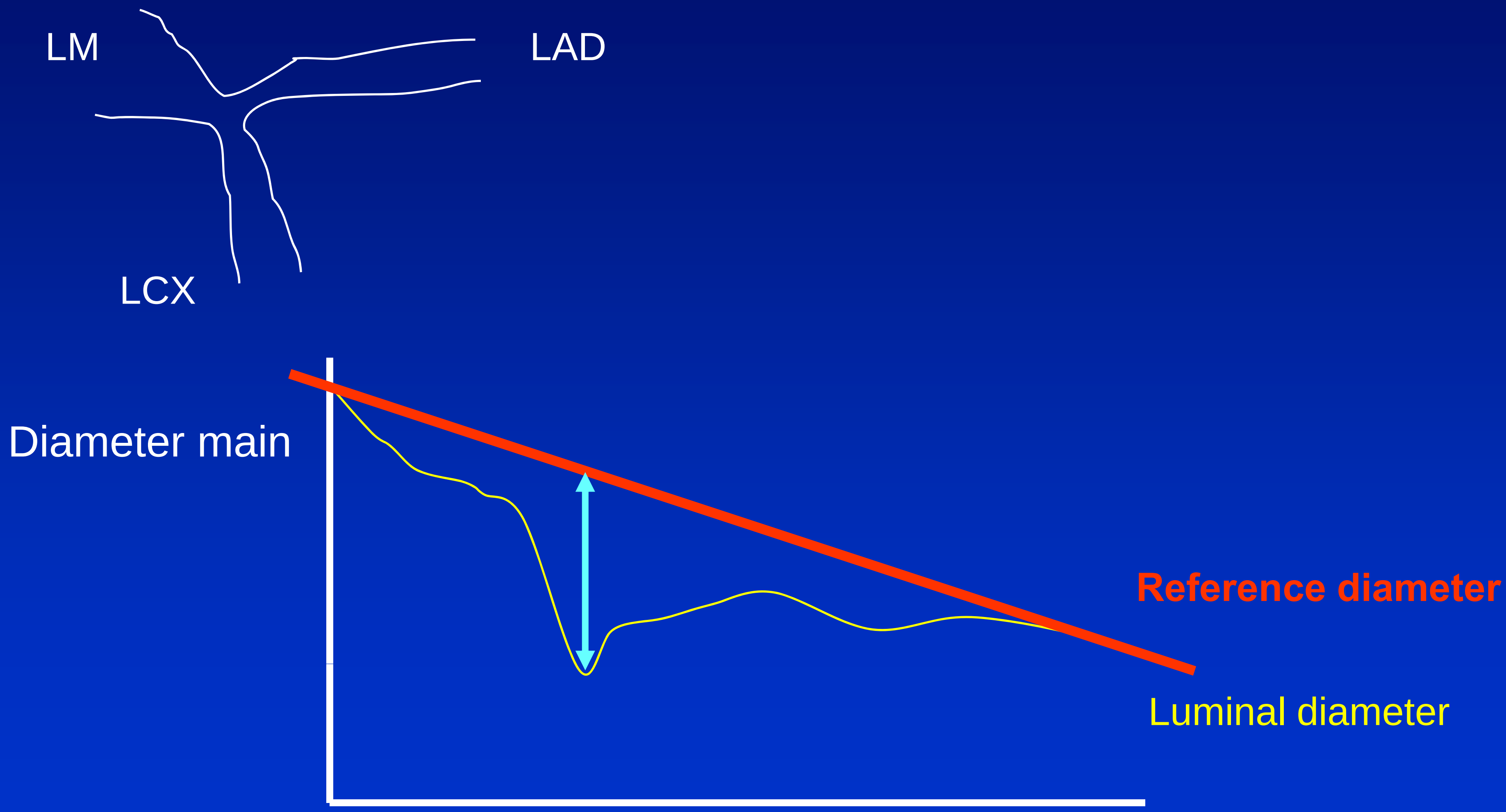
- MLD = 1.3
- Mean reference: (3.5+2.2) / 2 = 2.85
  DS = (2.85-1.3) / 2.85 X 100 = 54.4%
- Interpolated reference: 3.2
  DS = (3.2-1.3) / 3.2 X 100 = 59.4%

- MLD = 0.5
- Mean reference: (3.5+2.2) / 2 = 2.85
  DS = (2.85-0.5) / 2.85 X 100 = 82.5%
- Interpolated reference: 2.5
  DS = (2.5-0.5) / 2.5 X 100 = 80.0%



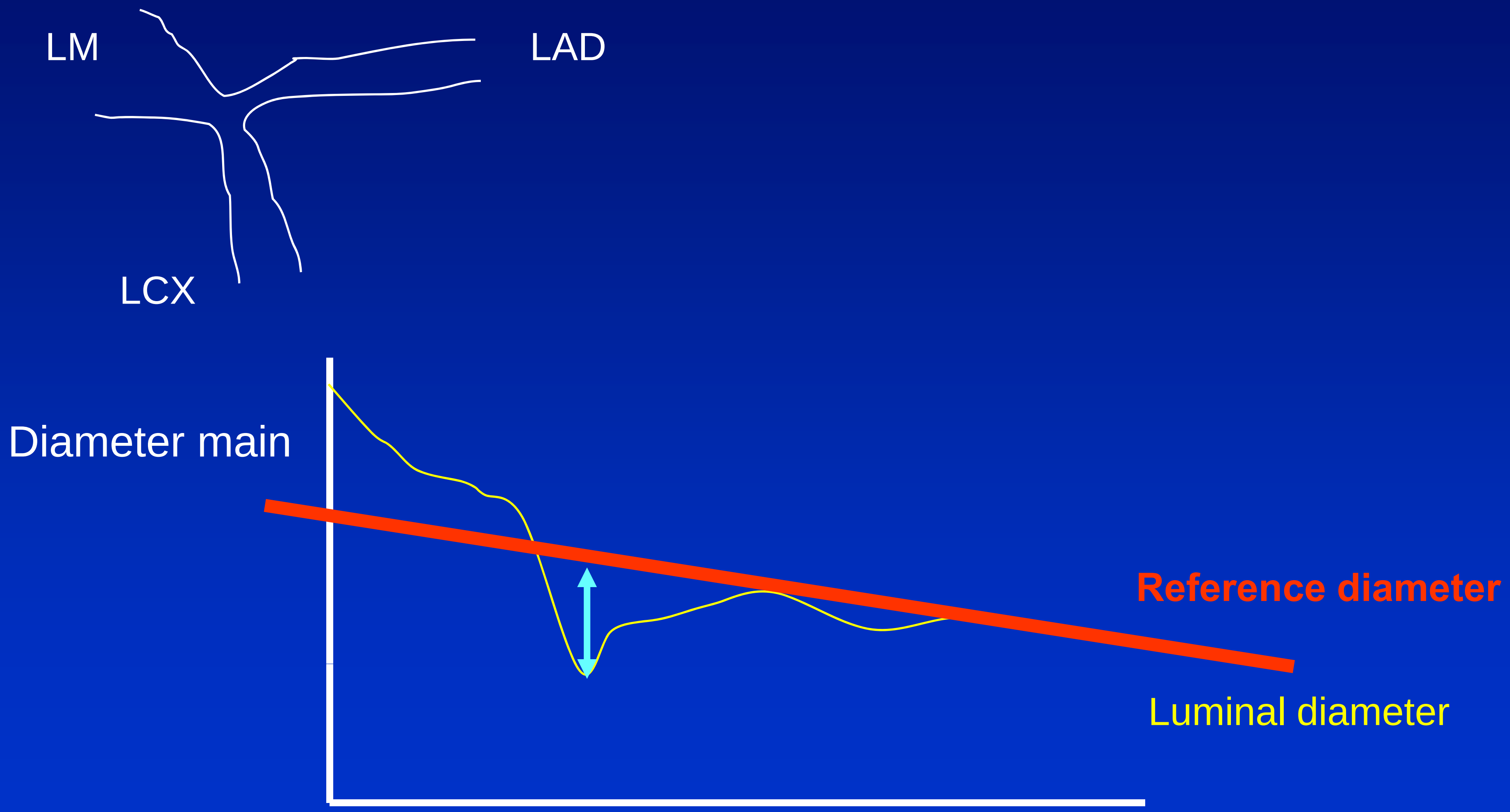
Courtesy of YH Kim

Interpolated Reference of Bifurcation Not easy…



Courtesy of YH Kim

Interpolated Reference



Courtesy of YH Kim

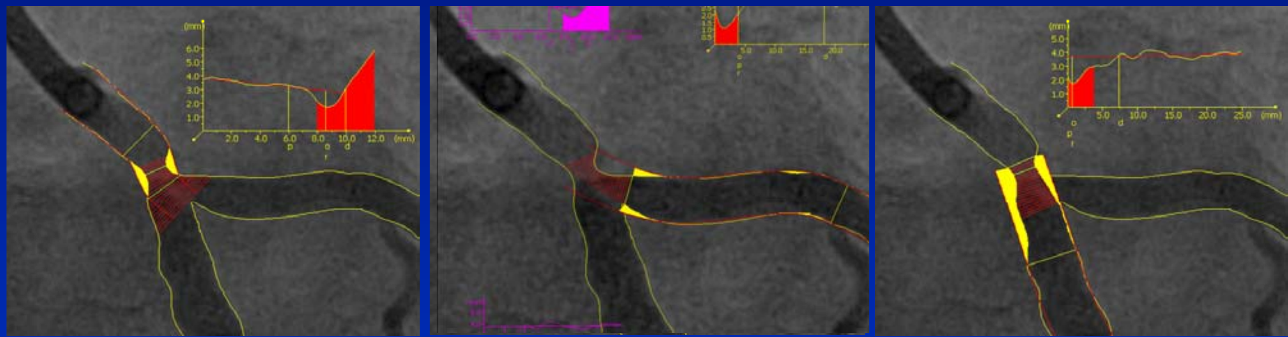
Interpolated Reference

Courtesy of YH Kim

Limitation of Current QCA Software Different Results for Same Lesion

Artificial "interpolation" of RVD across carina

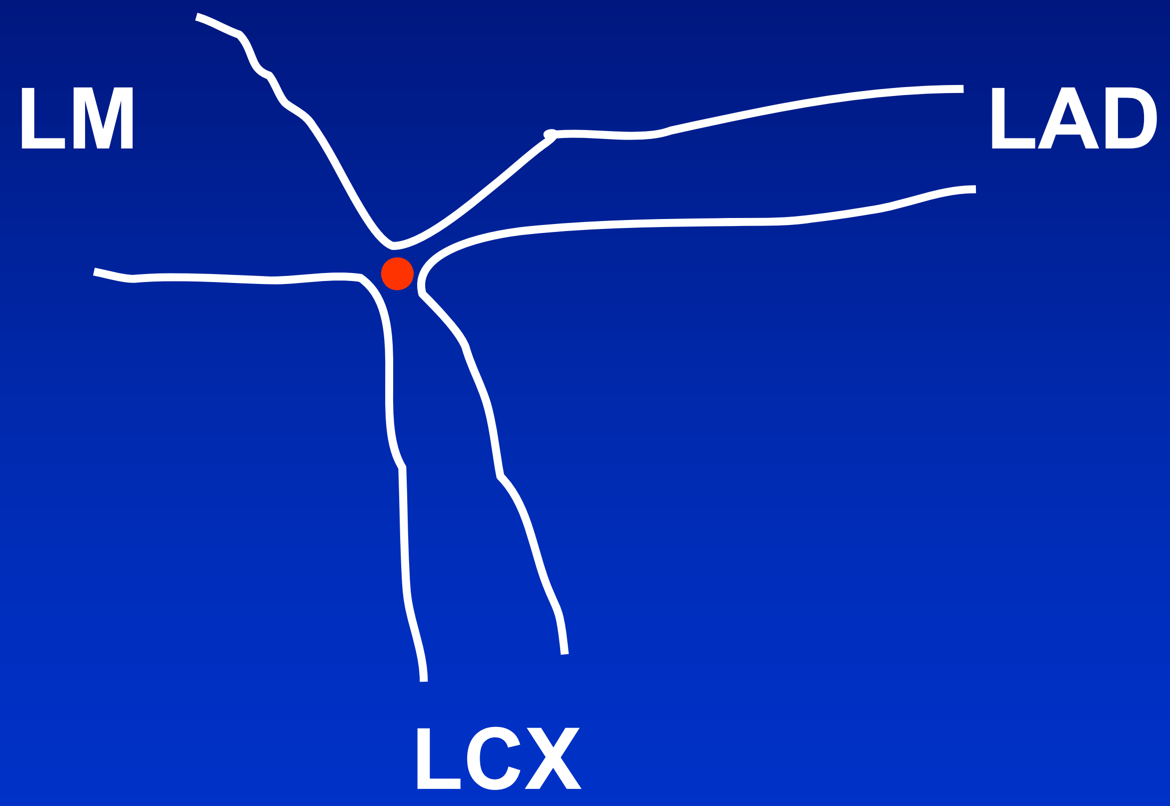
Carinal segment reported 3 times with differing results



LCA Main (selected)	LAD Proximal (selected)	LCX Proximal (selected)
Obstruction diam. 1.72 mm	Obstruction diam. 2.02 mm	Obstruction diam. 1.71 mm
Reference diam. 2.92 mm	Reference diam. 3.13 mm	Reference diam. 3.70 mm
Diameter stenosis 41.15 %	Diameter stenosis 35.45 %	Diameter stenosis 53.74 %
Obstruction length 3.98 mm	Obstruction length 14.36 mm	Obstruction length 7.35 mm

Slide of Lansky A

Confusion
The spot is LM, LAD, or LCX ?

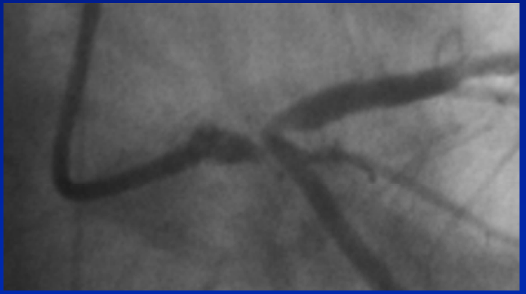


Courtesy of YH Kim

Murray's Law

$$D_{mother} = 0.67 * (D_{daughter\ 1} + D_{daughter\ 2})$$

$$Ref. = 0.67 * (MB + SB)$$



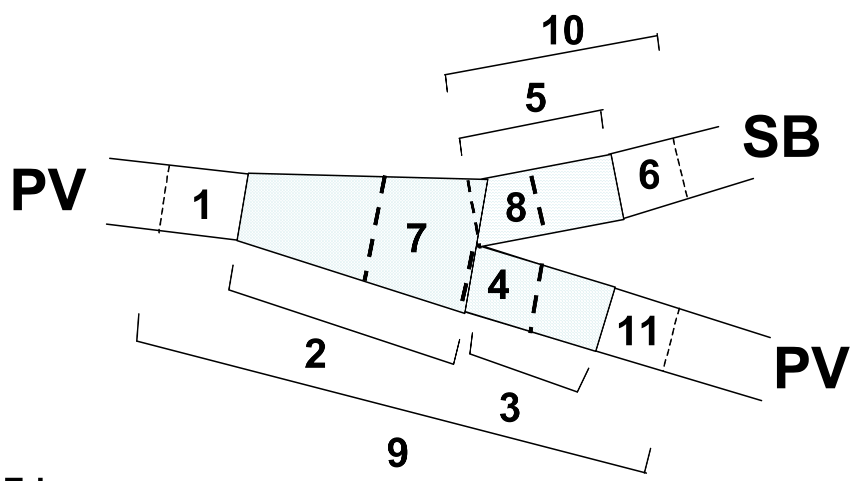
Relative deviation between the expected diameter of the mother vessel calculated with this formula and the measured diameter:

-1.27% ± 9.85%

Yifang Zhou. Phys. Med. Biol. 1999;44:2929

QCA Methods for Bifurcation Lesions

QCA Methods and Reporting



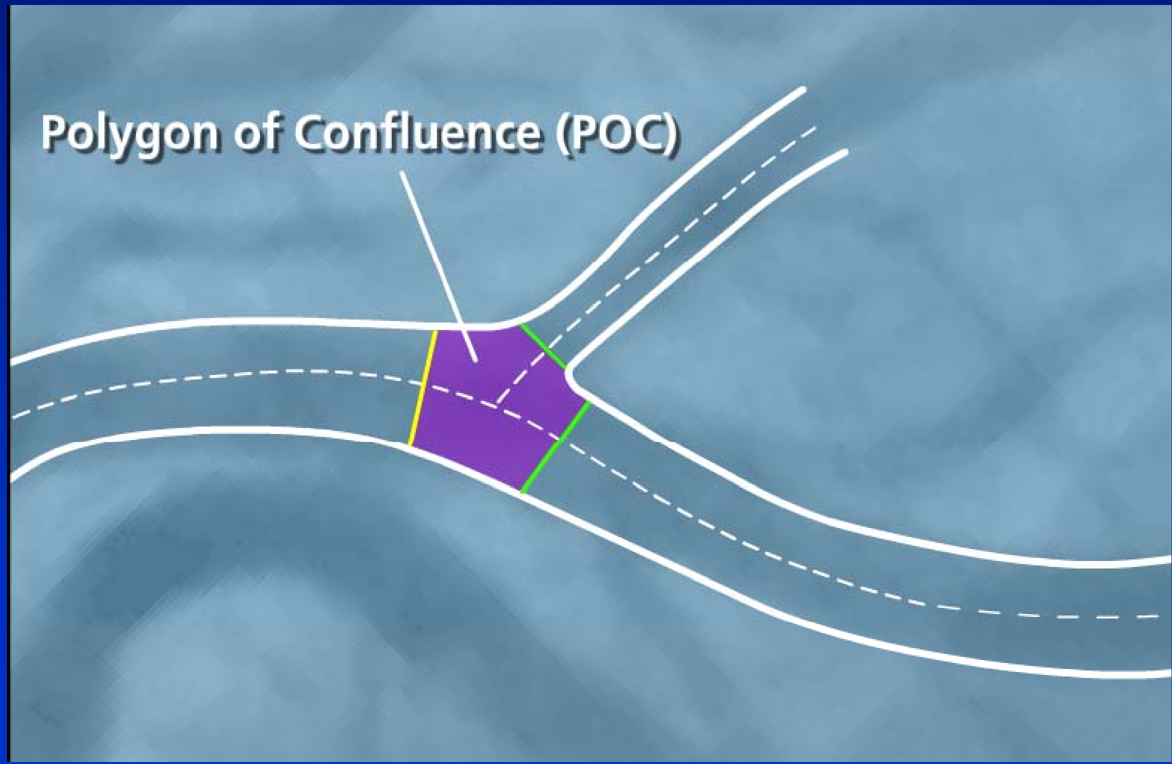
1 – Proximal Edge
2 – Proximal Stent
3 – Distal PV Stent*
4 – Ostium of distal PV (5mm)
5 – SB Stent*

6 – Distal Edge of the SB Stent*
7 – Carina
8 – Ostium of the SB (5mm)
9 – PV In-Lesion
10 – SB In-Lesion
11- distal edge PV Stent

**if additional stent(s) placed*

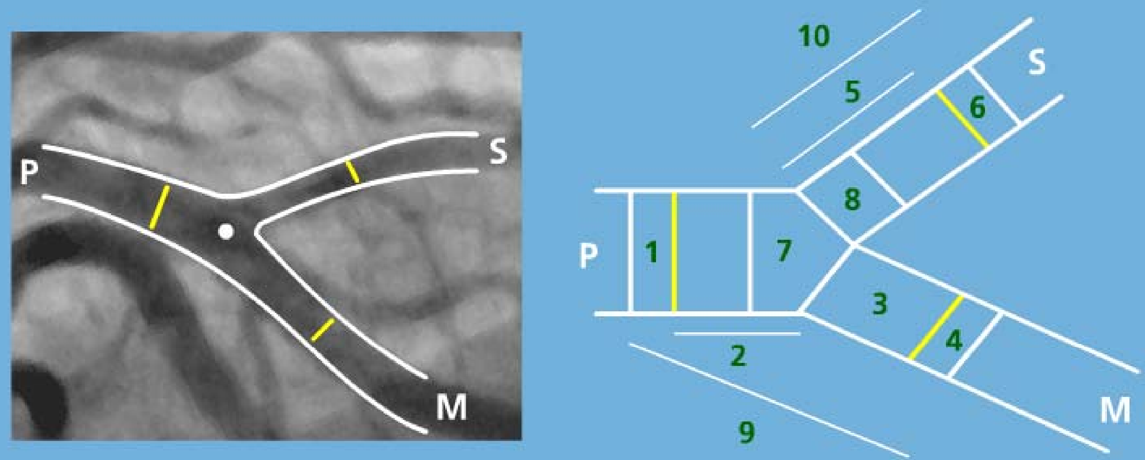
A. Lansky, JACC Intervention 2008, In press

Polygon of Confluence by CASS-QCA
: Innovative Method of Bifurcation QCA



Courtesy of YH Kim

Description of Bifurcation QCA



1. Proximal edge (5mm)
2. Proximal main stent
3. Distal main stent
4. Distal edge main (5mm)
5. Side branch stent
6. Distal edge side (5 mm)
7. Polygon of confluence
8. Ostium of side branch (5mm)
9. Main vessel stent + edges
10. Side branch stent + distal edge

Presenting results in segmental model

Courtesy of YH Kim

Description of Bifurcation QCA

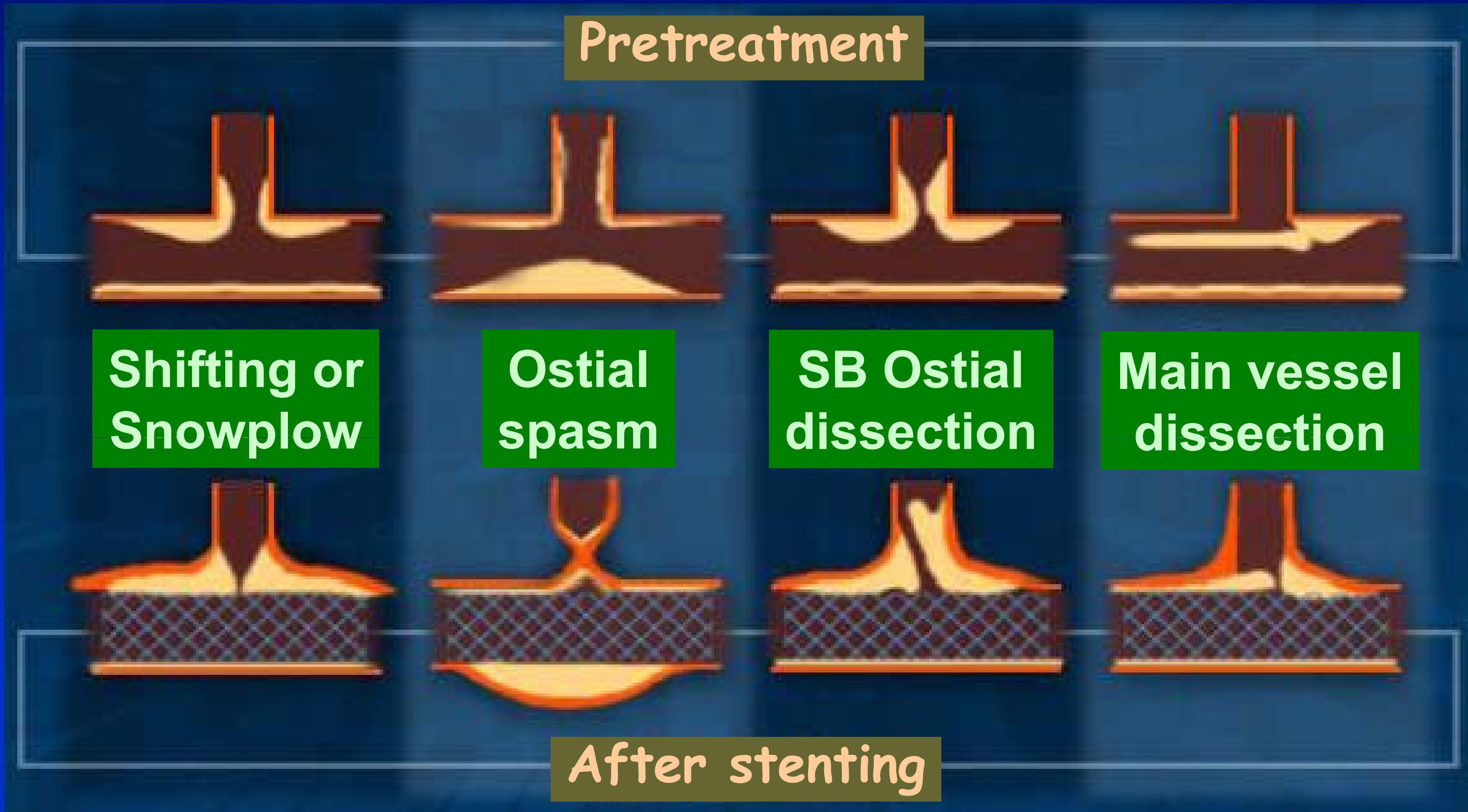
Other important parameters

- Bifurcation angle
- TIMI flow in both branches
- Degree of calcifications
- Uneven or ulcerated segments
- Concentric or eccentric locations of MV lesions
- Contra- or ipsi-lateral MV plaque location
- Length of SB stenosis

PCI for Bifurcation Lesion

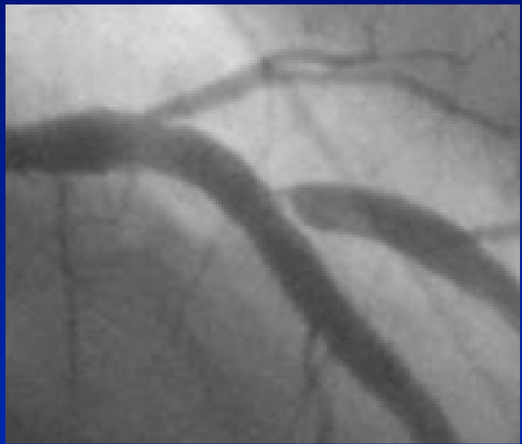
Side Branch Loss

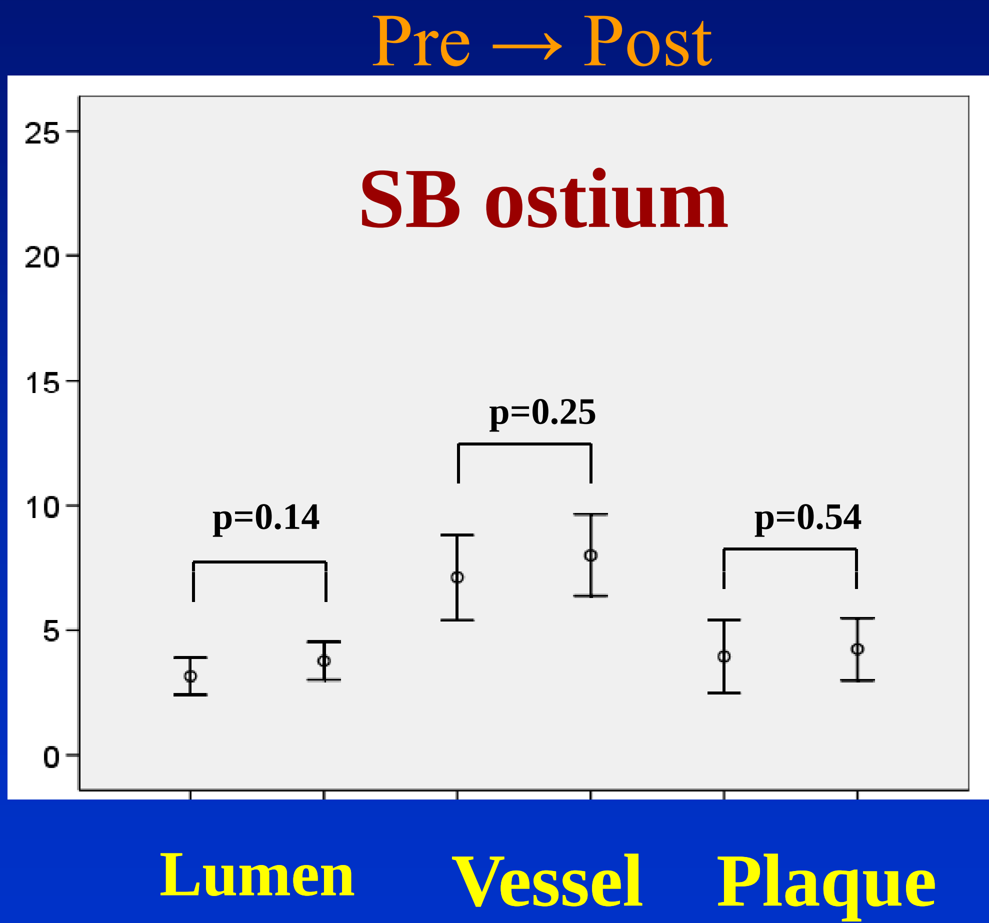
Main Mechanism of Adverse Outcomes

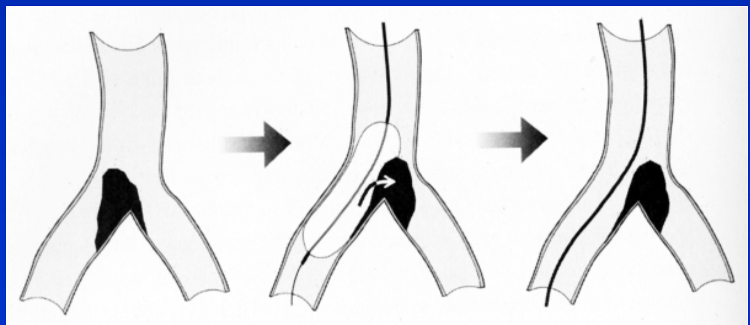


~~Plaque~~ Carina Shift

INSIGHT – IVUS

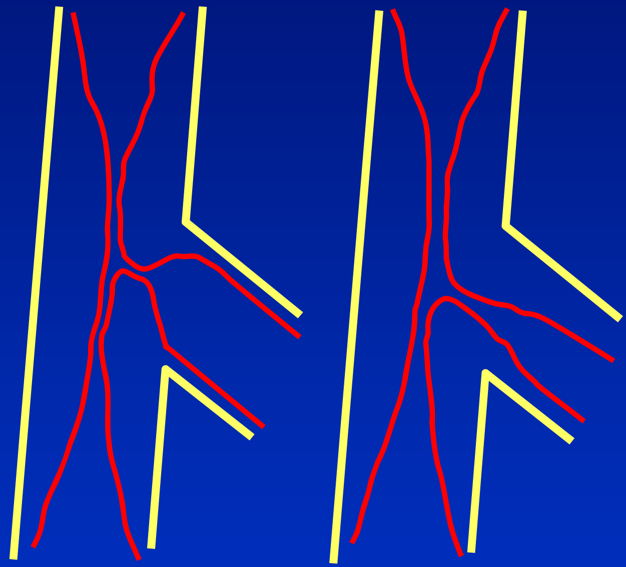


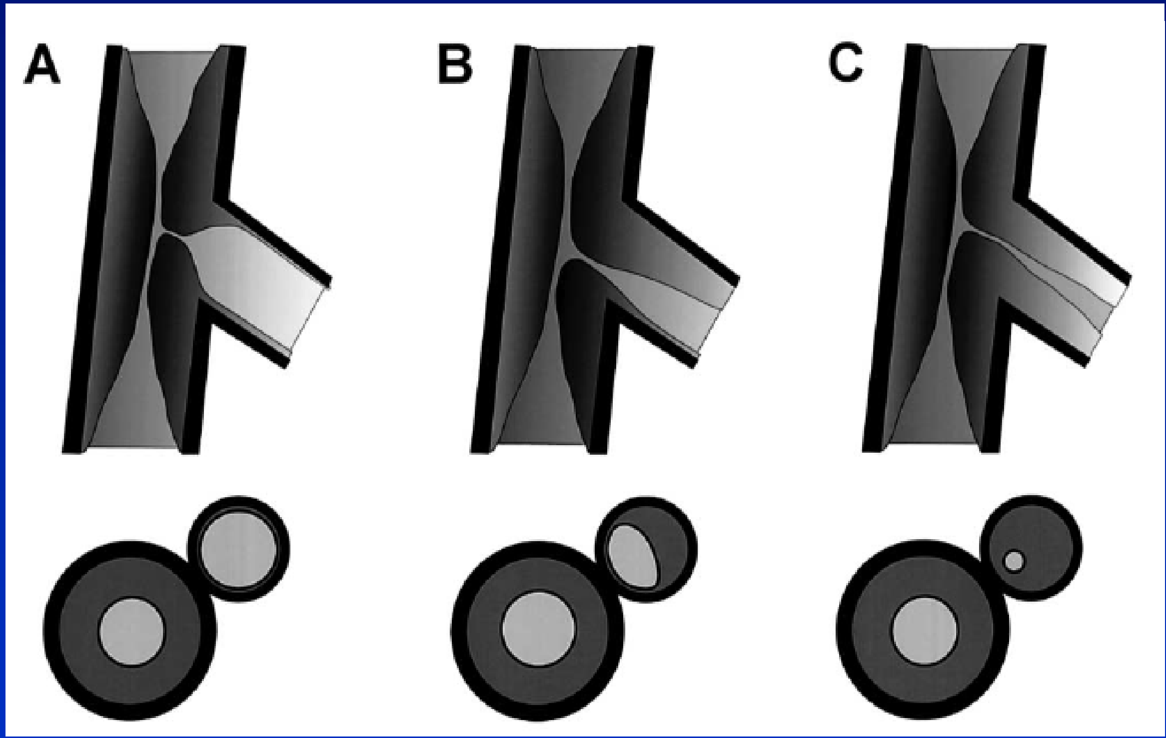




Costa MA, TCT 2007

IVUS Predictors of SB Occlusion





SB occlusion A vs B+C: 8.2 vs 35.0 %; p=0.003

Furukawa. Cir J 2005;69:325

SB Jailed Wire

- Helps to keep the SB open
- Useful in case of SB closure
- Change the angle btw proximal MB & SB
- Difficult? → more after MB stenting!

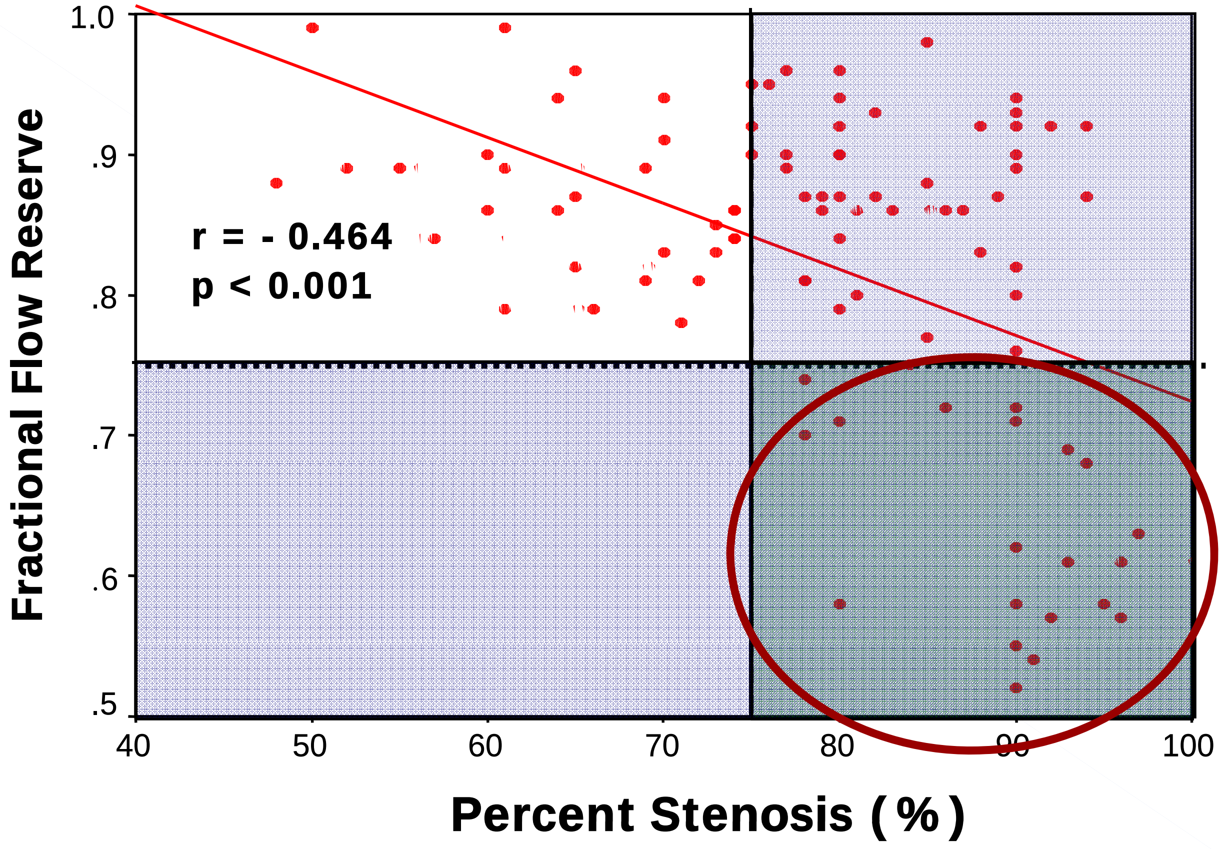
SB Predilation

- Cons
  - Unnecessary trauma or dissection
- Pros
  - To assess how the lesion will behave
  - To optimise subsequent stent expansion, esp. calcified SB
  - To better evaluate the most appropriate stenting strategy
  - To facilitate subsequent re-wiring if >90% baseline stenosis
  - To reduce the potential for ischemia during the procedure

Is All Jailed SB Important?

QCA vs. FFR

Jailed side branch lesions (n=94)



27% of SB lesions

>75% stenosis

FFR <0.75

Koo BK, JACC 2005;46: 633

Simple vs. Complex Technology

- **Simple stenting technique**

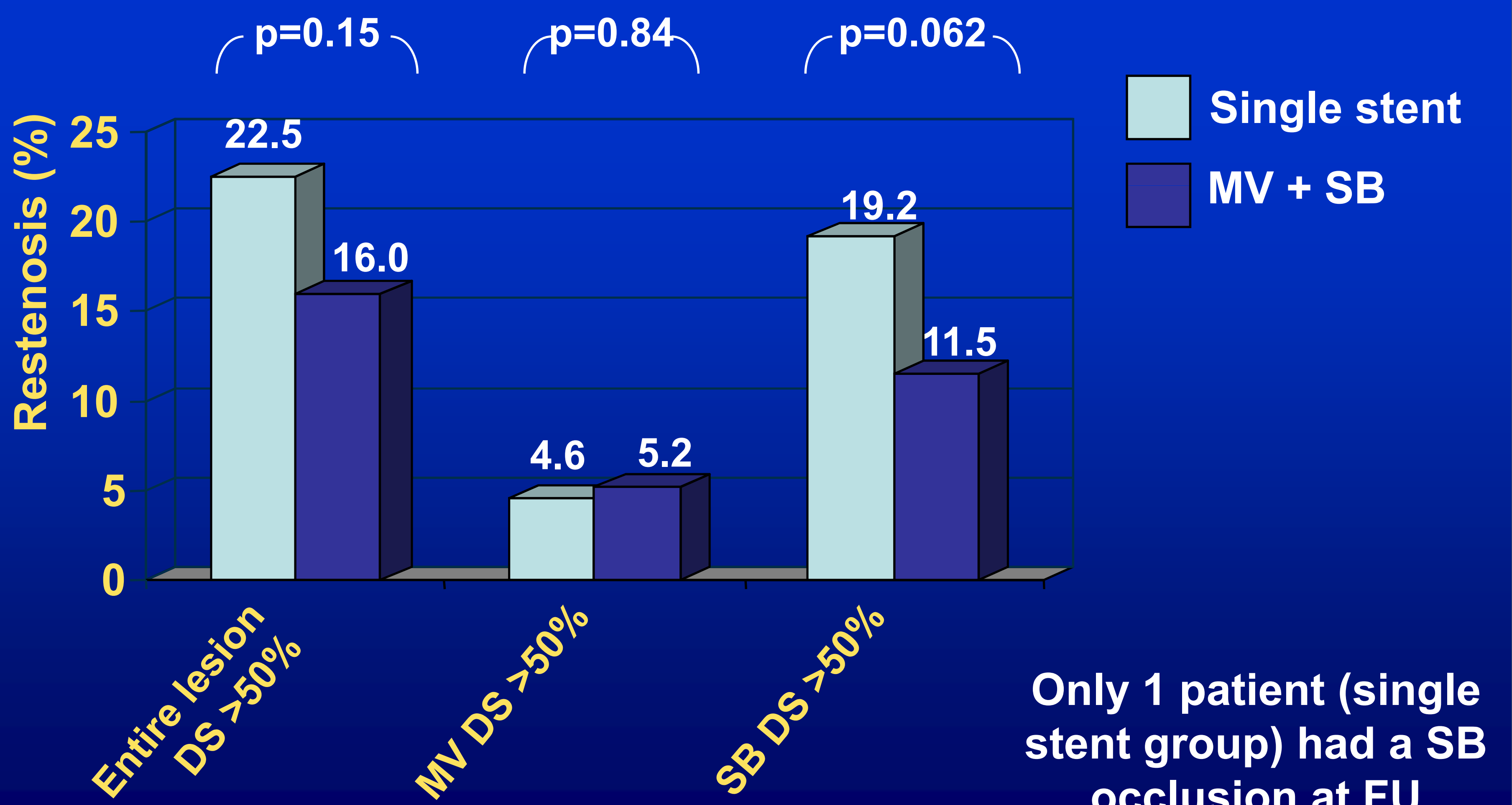
  DES implantation only at the main vessel with optional balloon angioplasty or stenting at the side branch

- **Complex stenting technique**

  DES implantation at the main vessel and the side branch

DES in Bifurcation; Restenosis

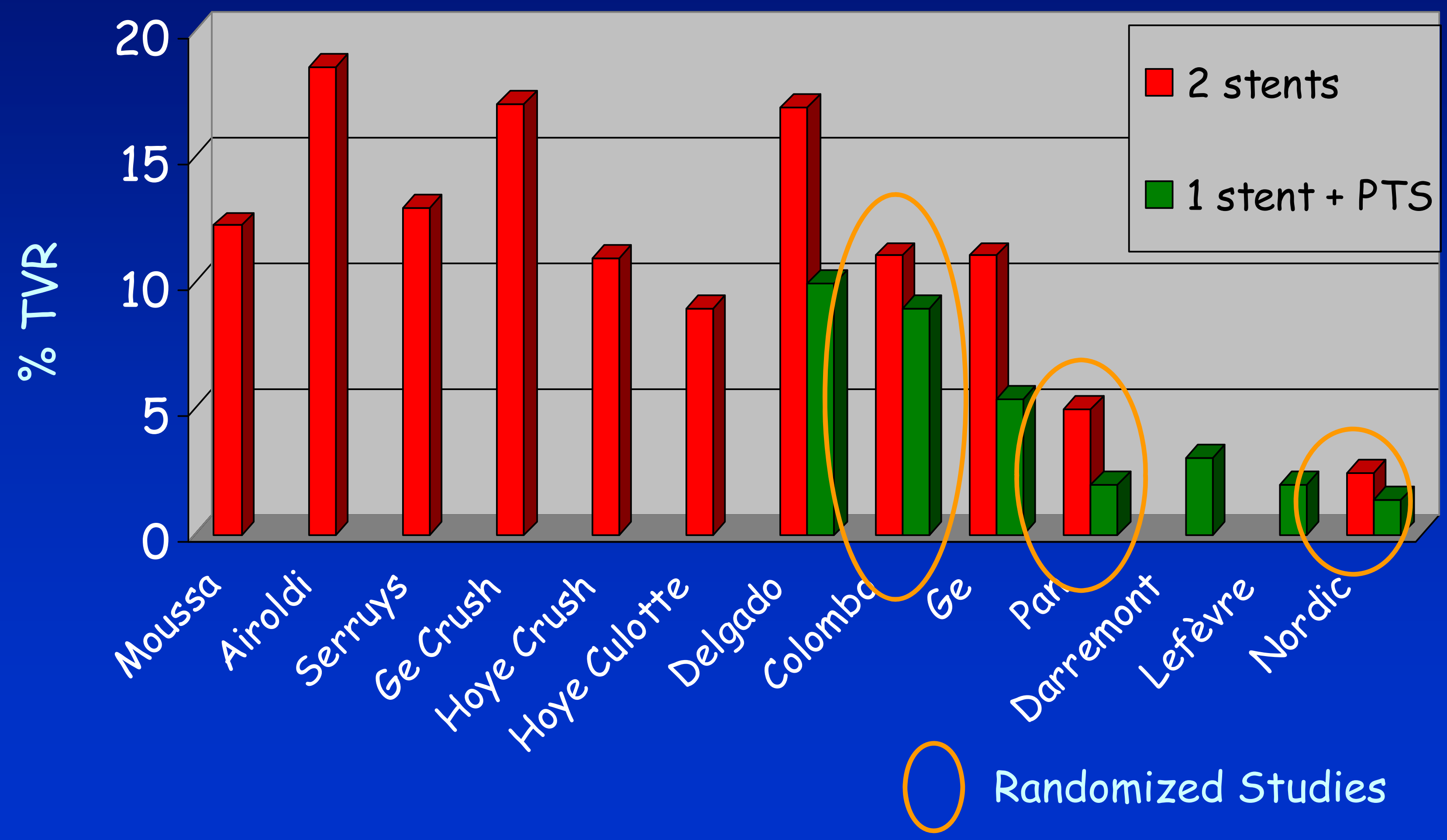
NORDIC Bifurcation



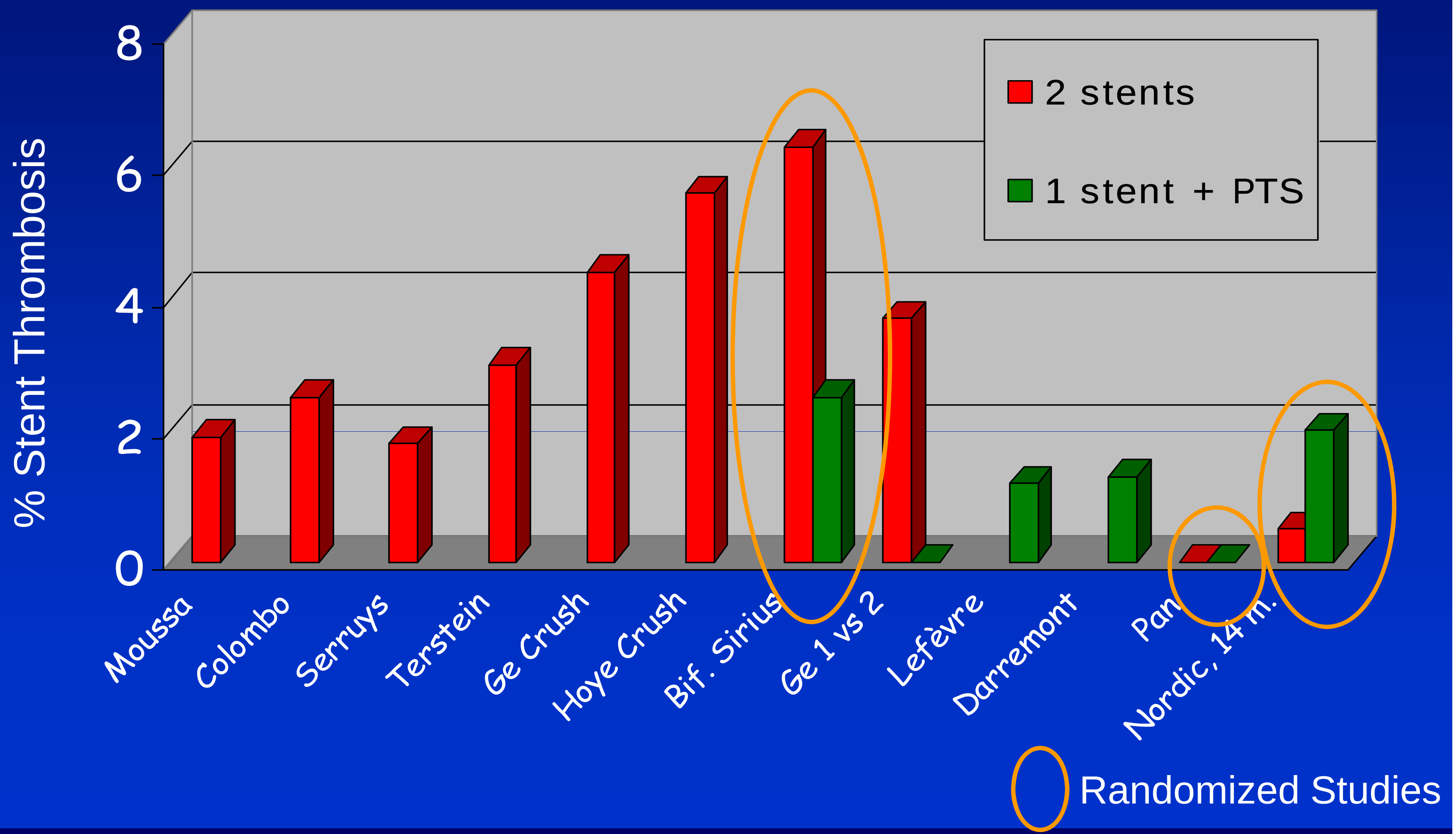
Only 1 patient (single stent group) had a SB occlusion at FU

Steigen et al Circulation 2006;114:1955-61

DES in Bifurcation; TLR



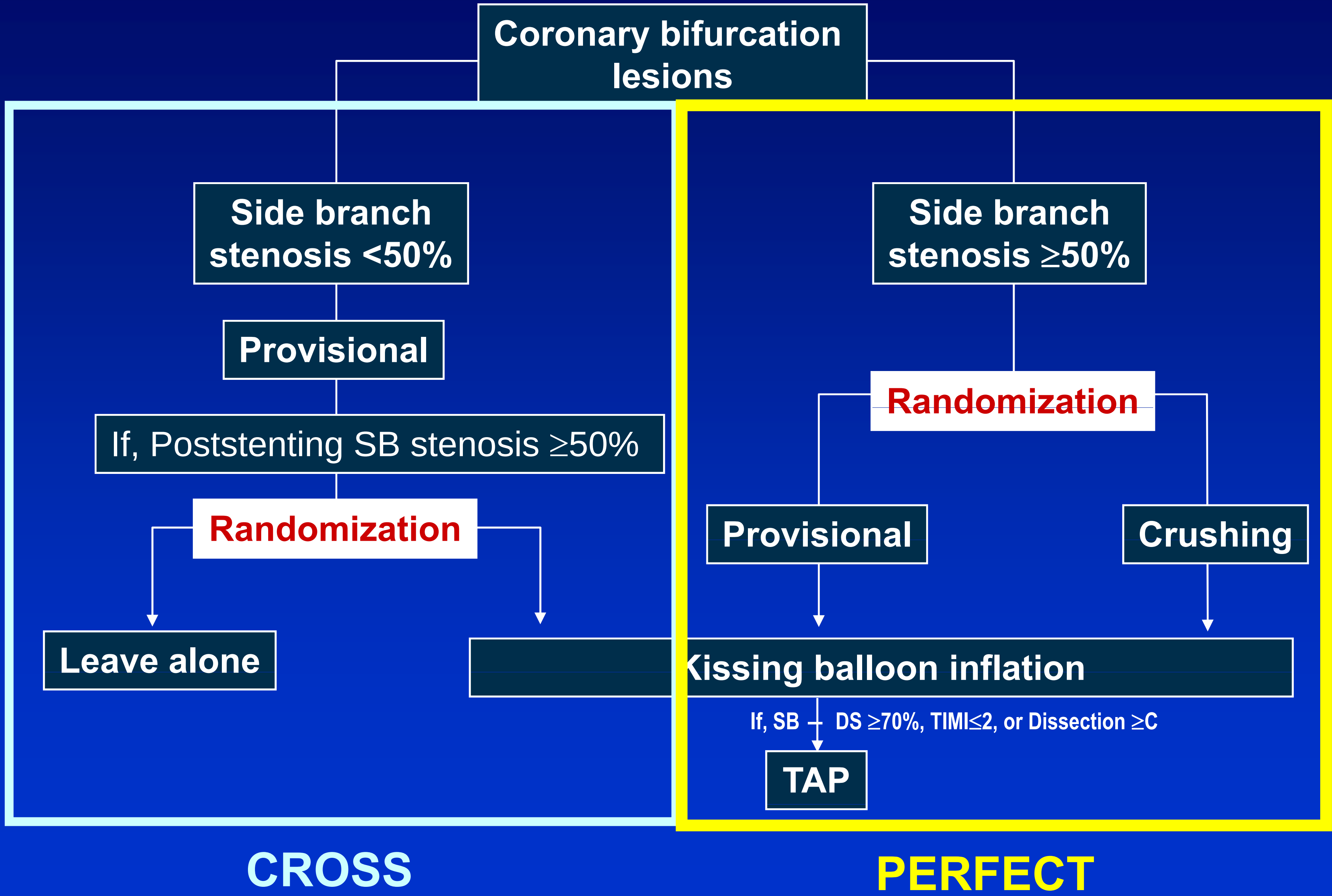
DES in Bifurcation; Safety



Ongoing Randomized Trials

	N	Strategy
PRECISE	100	SKS vs. provisional
NORDIC II	425	Crush vs. Cullotte
NORDIC III	450	KB or not in Provisional strategy
CACTUS	350	Crush vs. Provisional T
PERFECT	500	Crush vs. Provisional T
CROSS	180	KB or not in Provisional strategy

PERFECT & CROSS



Simple Stenting Technique

Single stent with provisional strategy

Stent placement in the main branch only

and / or

1) Optional kissing balloon inflation

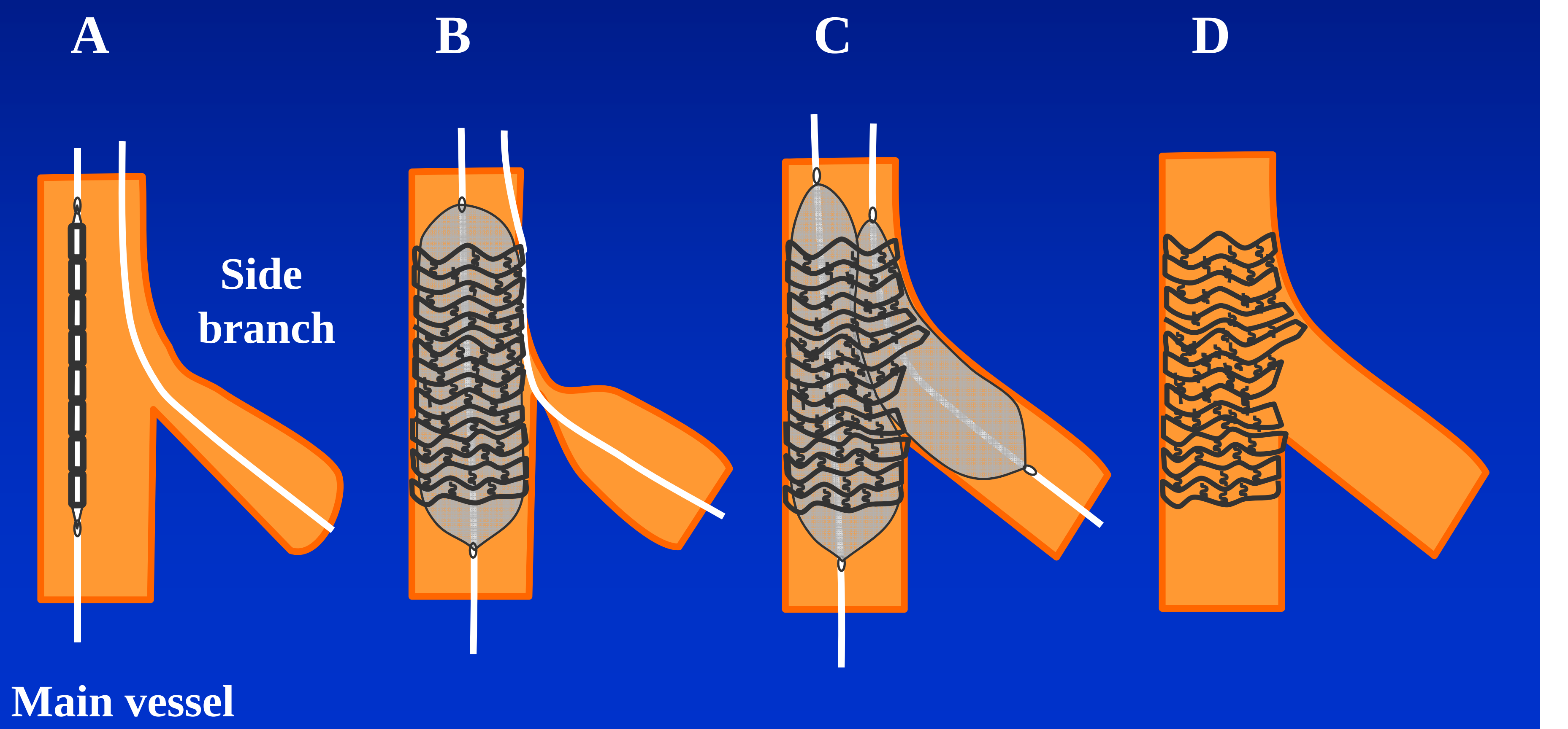
2) Provisional T stenting (TAP)

3) Provisional reverse crush technique

4) Provisional cullotte technique

Stenting Crossing Side Branch With Optional Kissing Balloon Inflation

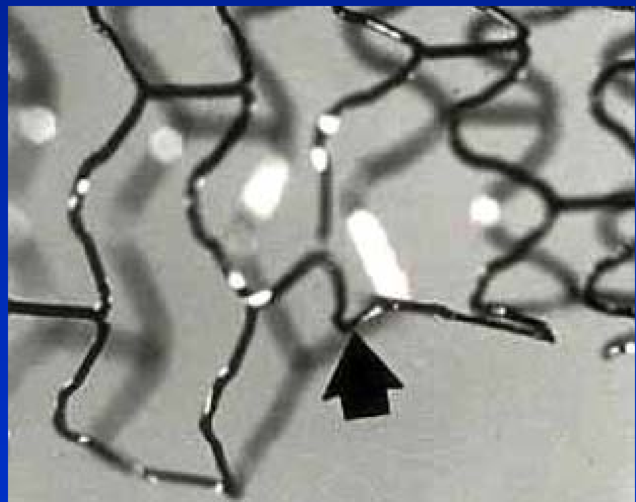
Normal or diminutive side branch ostium



Stent Distortion may

- Predispose to SAT
- Predispose to restenosis
- Limit subsequent access

Before KB



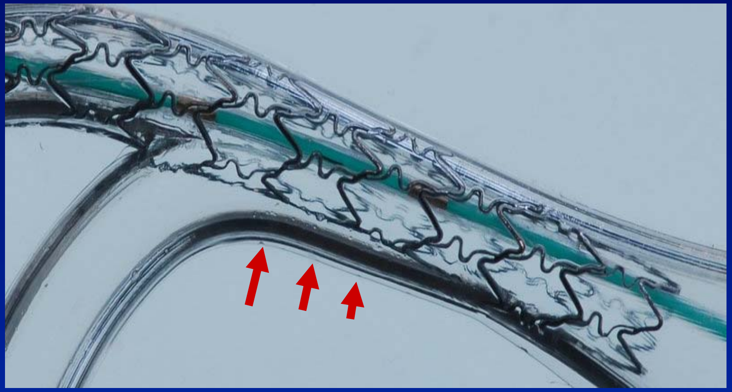
After KB

Ormiston CCI 1999;47:258

Proximal Optimization Technique

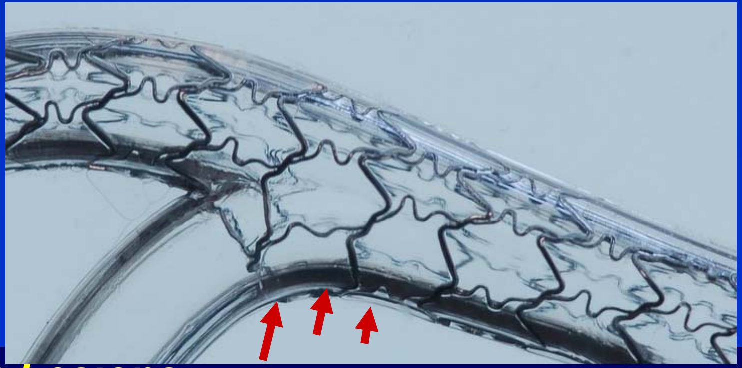
Cypher 3.5×23 mm

Before POT



Murray's Law
(3.5 + 3.0) x 0.67 = 4.35 mm

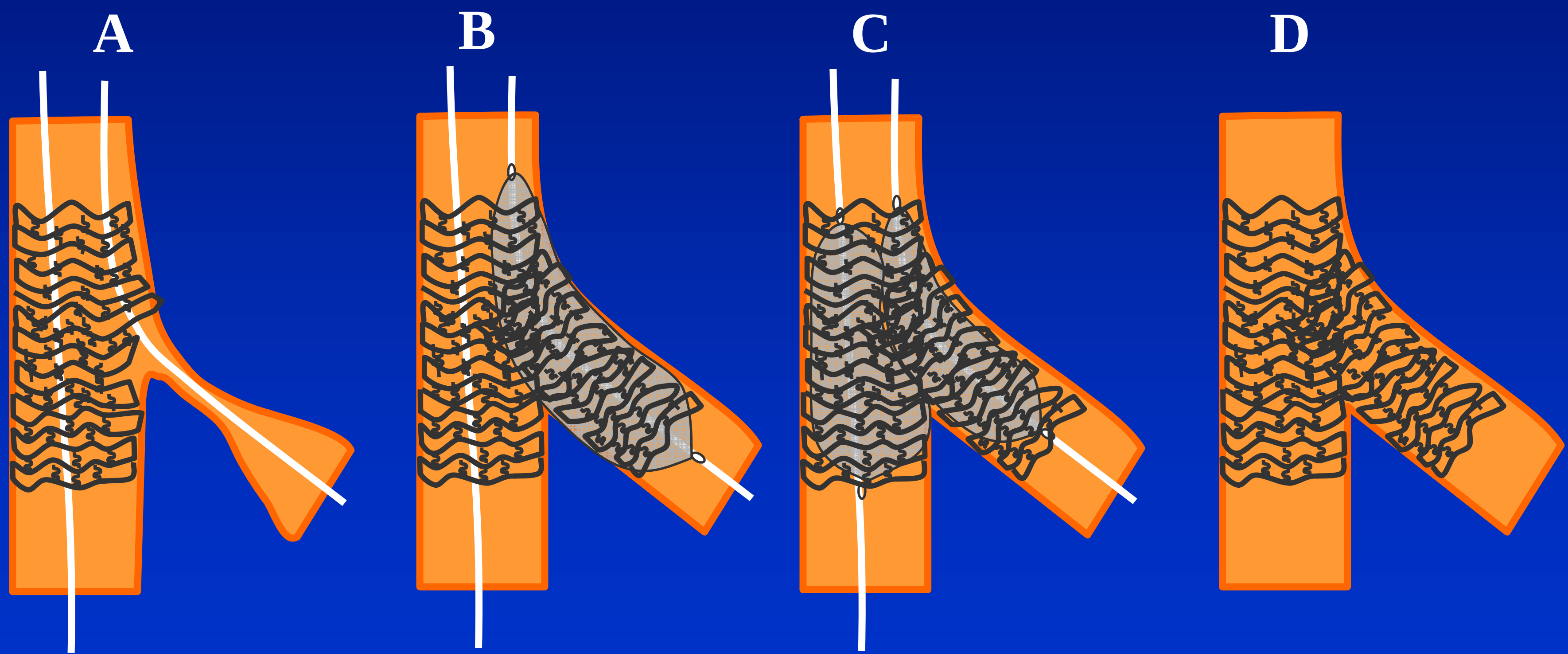
After POT



Darremont, EBC 2007

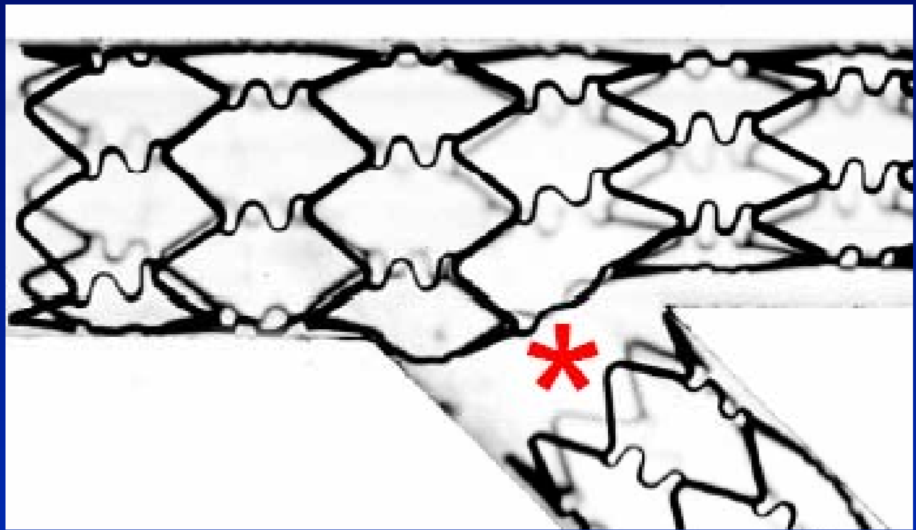
Provisional T Stenting

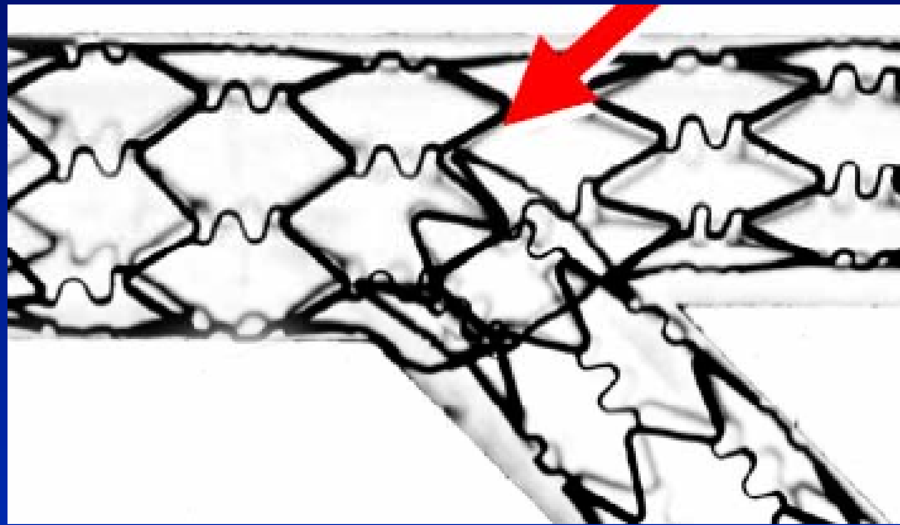
In cases with significant narrowing of side branch after main branch stenting



A	B	C	D
Jailed SB after MB stenting	**SB stenting with minimal protrusion**	**Final kissing is necessary**	**Slightly protruded stent strut to MB**

Tips of TAP Technique



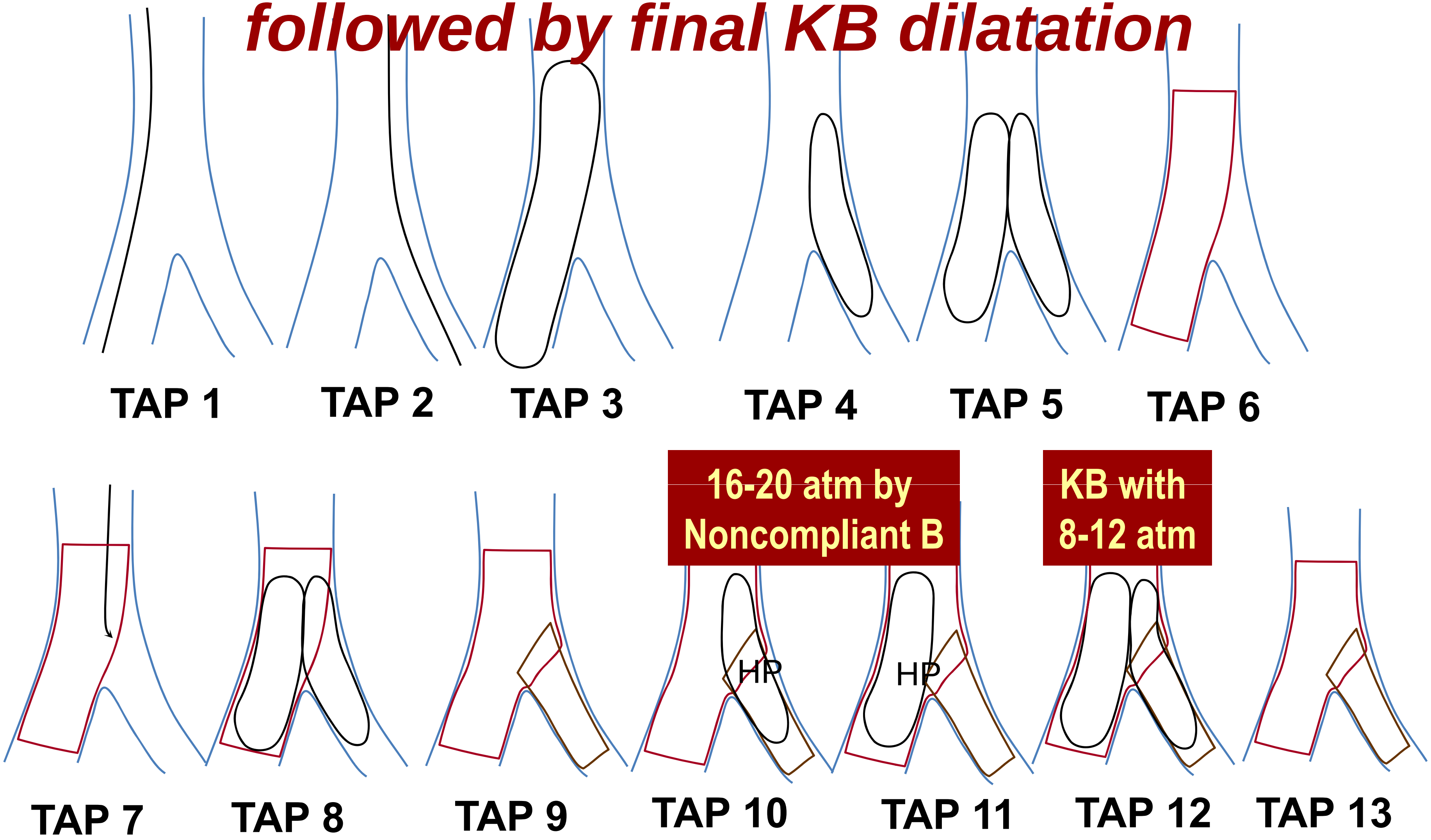


SB stent should not be too distal leaving gaps

SB stent should not be too proximal potentially Obstructing main vessel

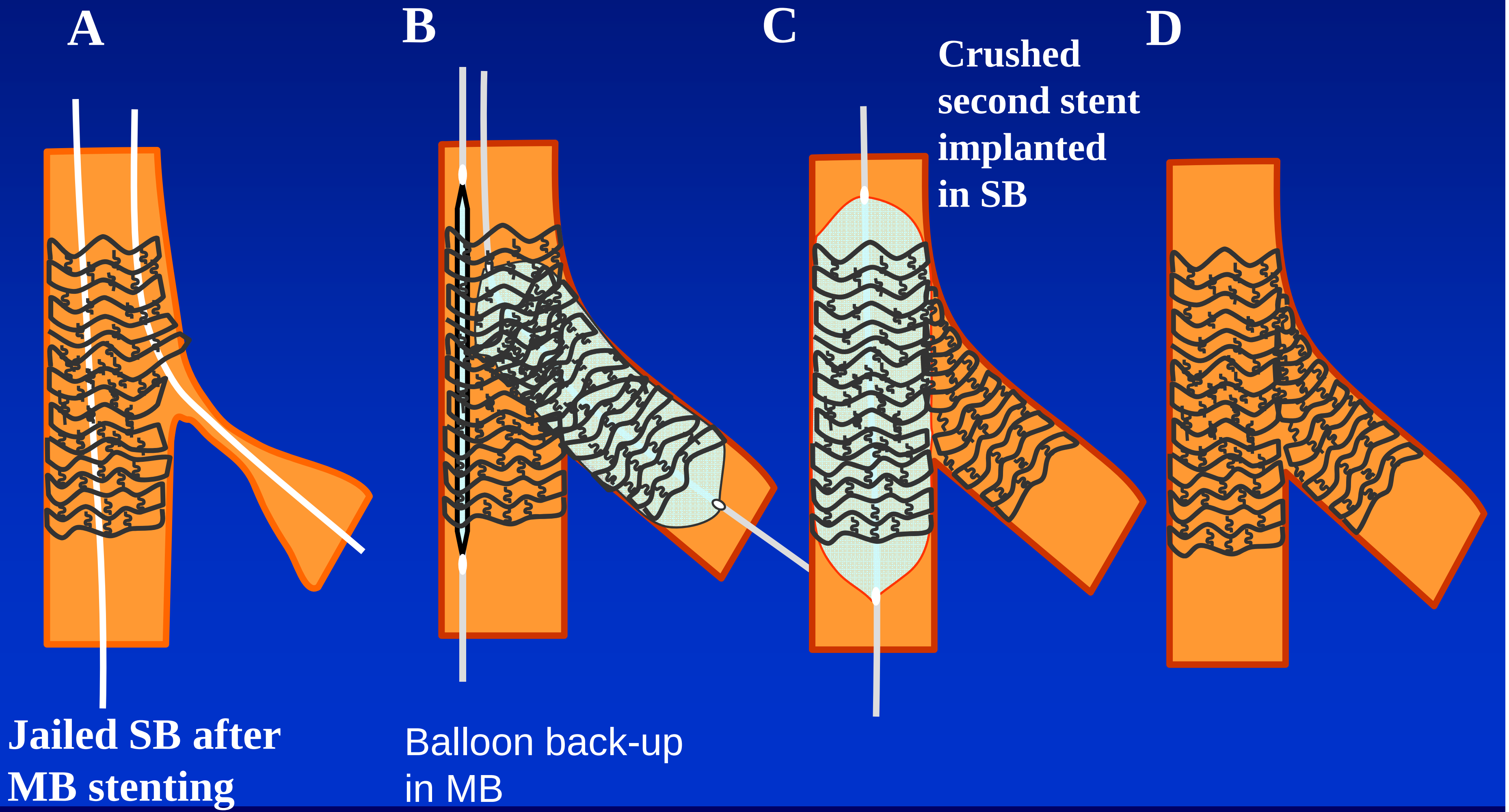
Tips of TAP Technique

High pressure sequential balloon dilatation followed by final KB dilatation



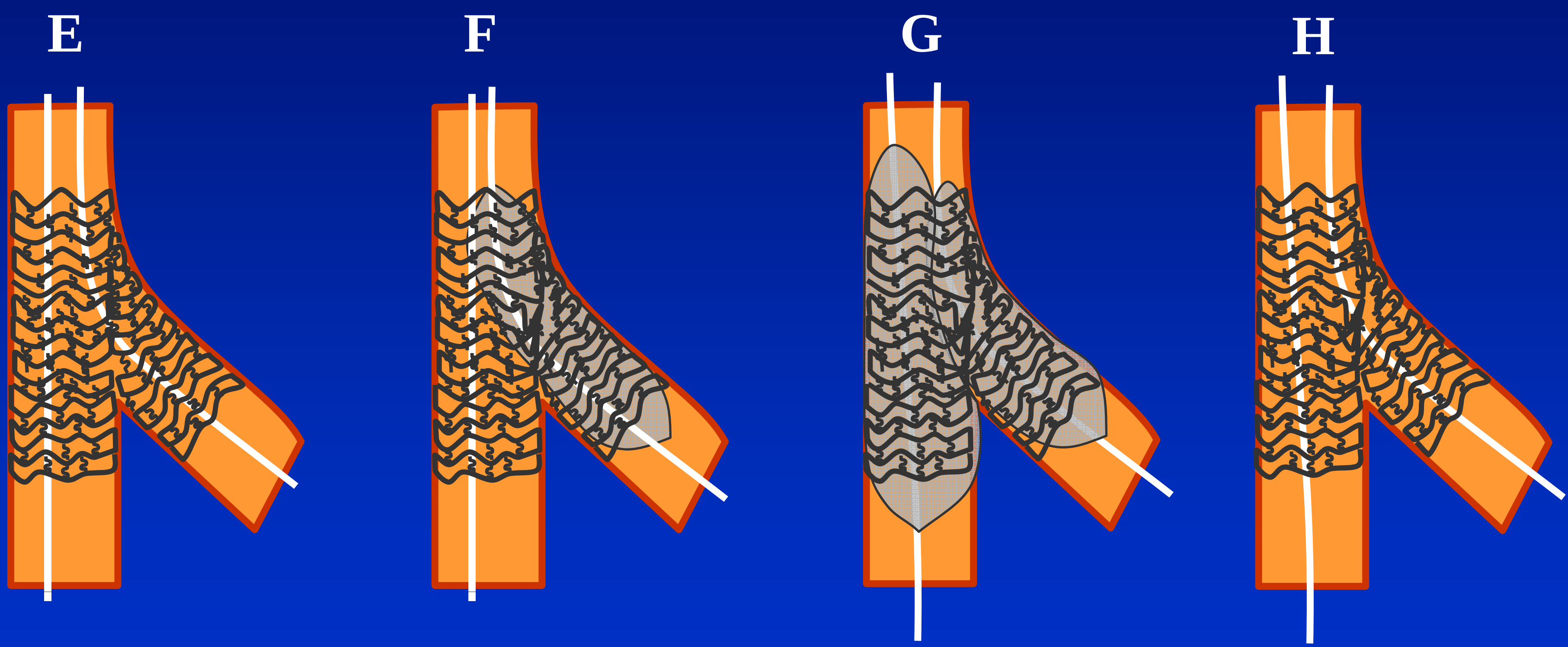
“Internal” or “Reverse” Crush

allows provisional SB stenting without strut protrusion



"Internal" or "Reverse" Crush

Final kissing balloon dilatation is mandatory

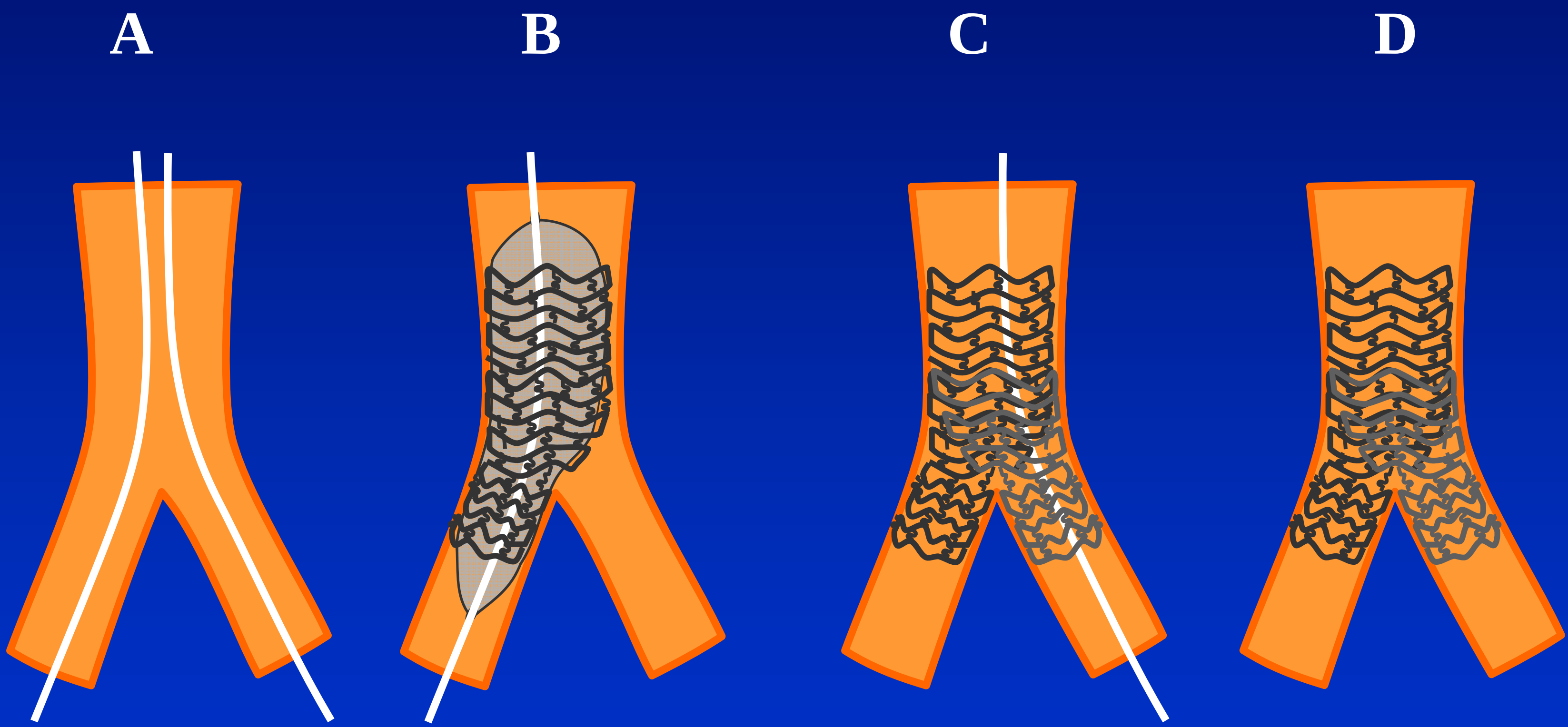


Re-advancement of wire into the side branch

Opening of the side branch ostium

Final kissing balloon inflation

Y (Culotte) Stenting



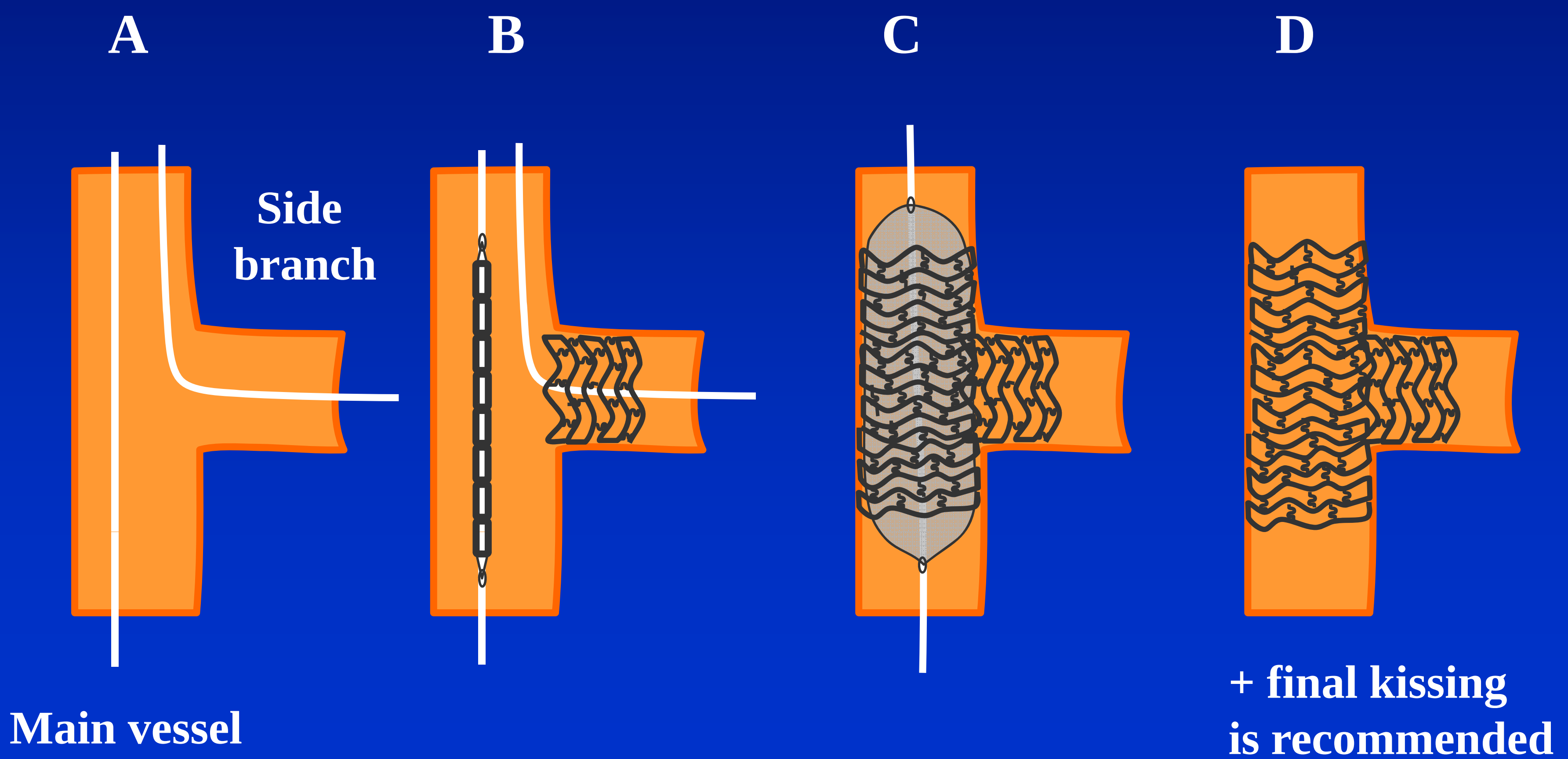
- Complete lesion coverage
- Too much stent overlap at the proximal segment

Complex Stenting Techniques

Planned two stenting technology

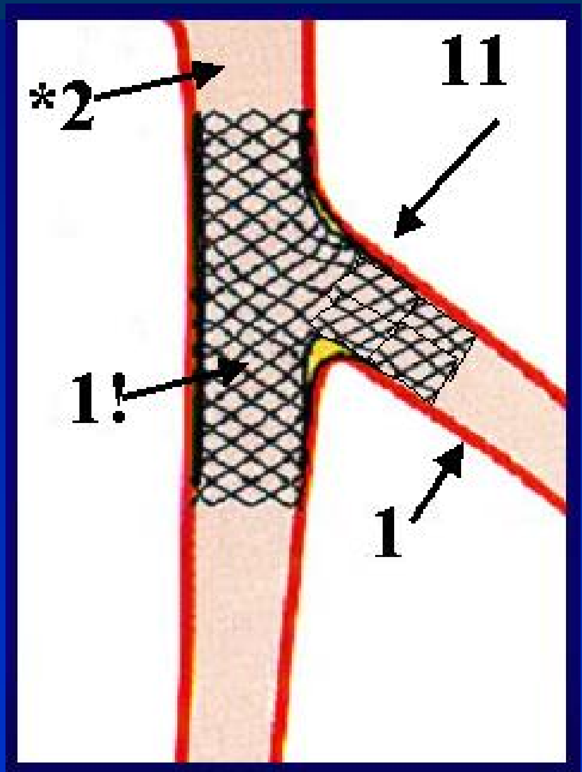
1. Modified T stenting
2. Crush
3. Mini-crushing
4. V stenting
5. Simultaneous kissing stenting

Modified T-Stenting

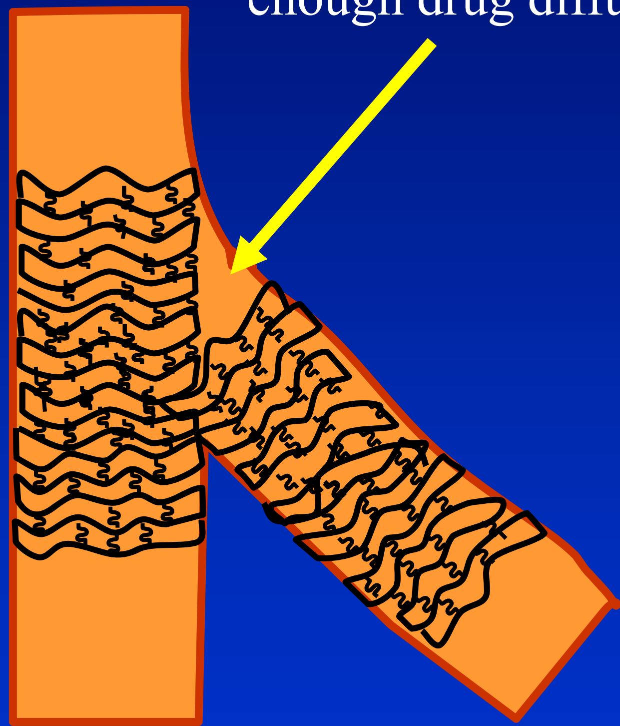


Limitation of Modified T Stenting

Restenosis site of T stenting in SIRIUS bifurcation



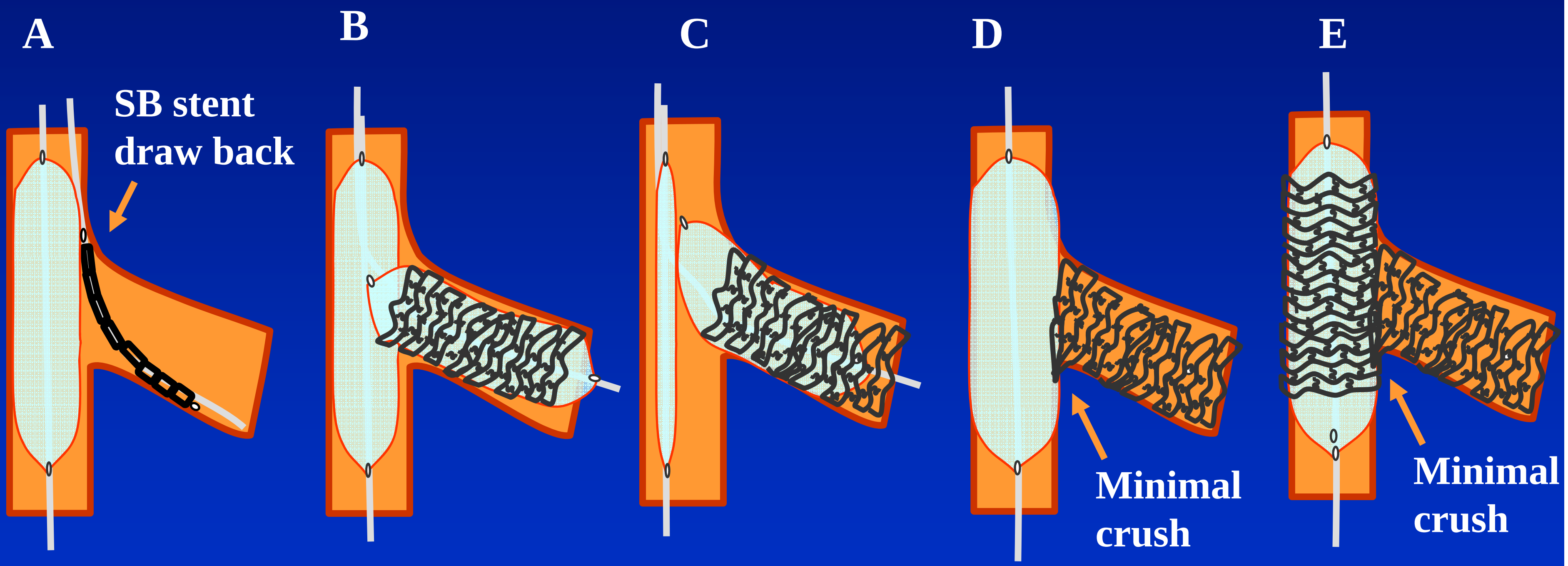
Potential gap without enough drug diffusion



To prevent potential gap at the ostial side branch, the first stent should cover the entire surface of the side branch.

Modified T-Stenting

For Proper Ostial positioning



MB balloon
4-6 atm

MB balloon 4-6 atm
SB stent 16 atm

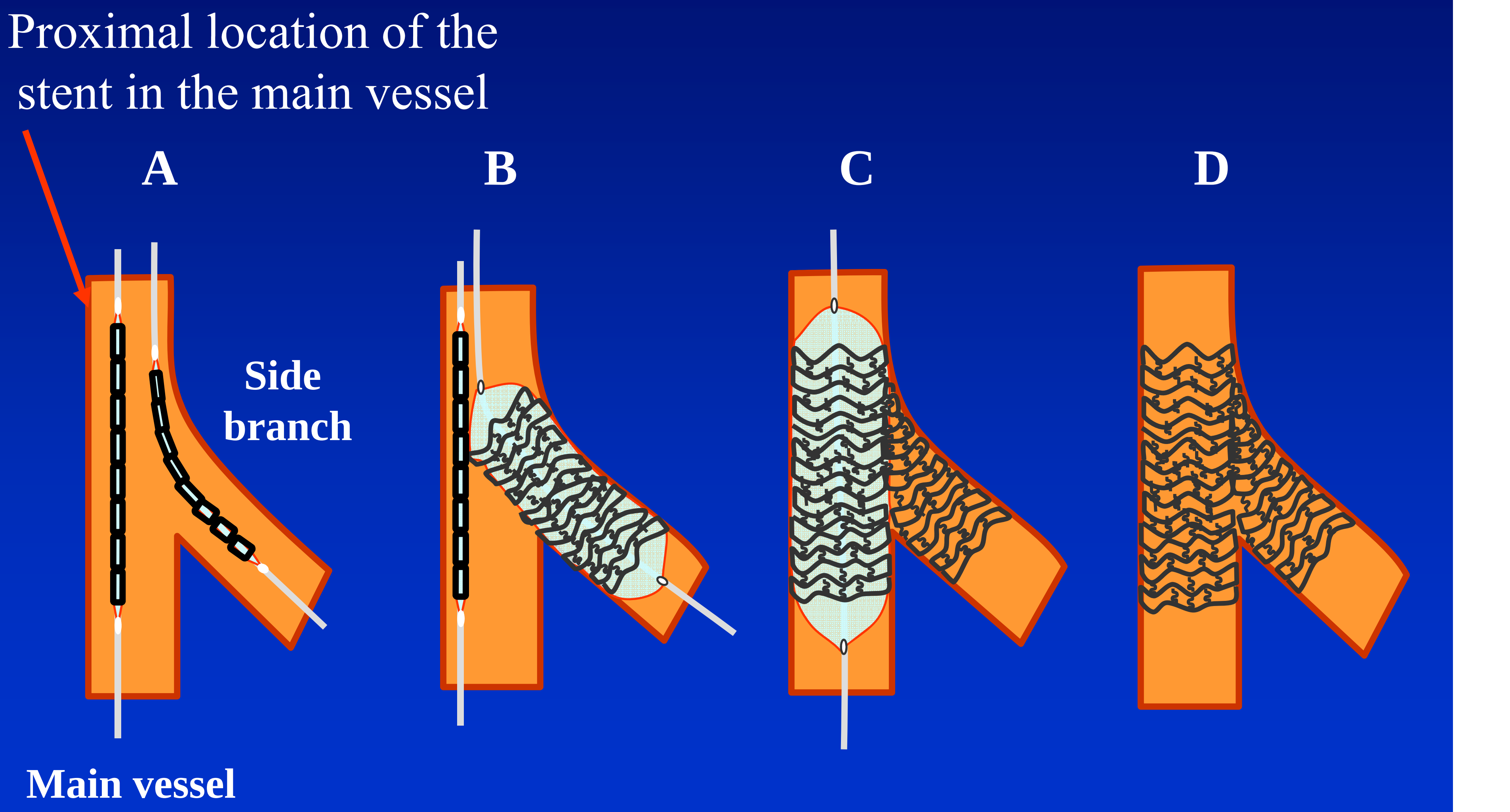
SB balloon
Pull back
18-20 atm

MB balloon
12-16 atm

MB stenting

Final kissing
recommended

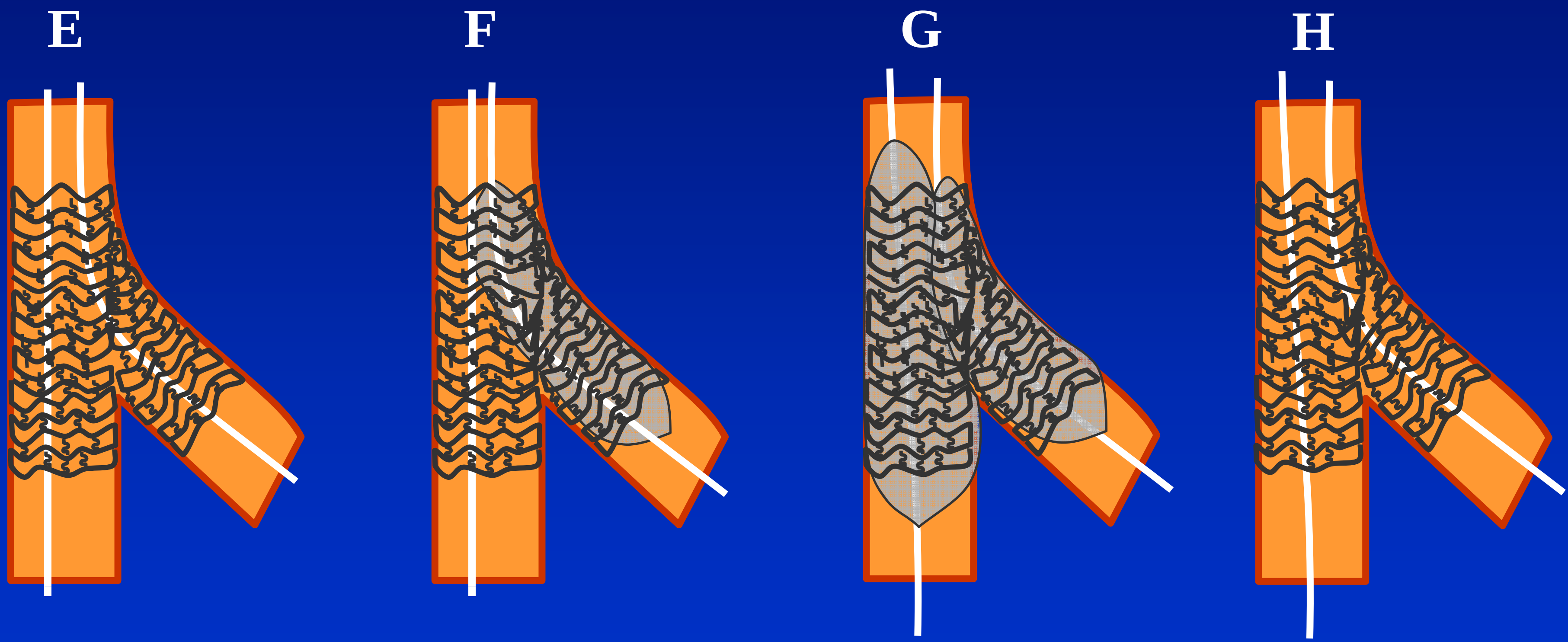
Crush Technique



One More Step of Crush Technique

Final Kissing Balloon Dilatation

for side branch re-opening and stent optimization



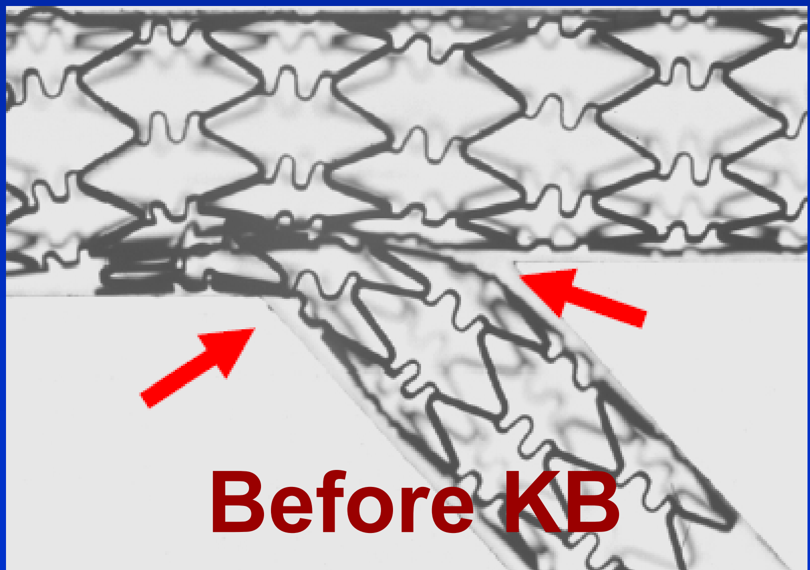
Re-advancement of wire into the side branch

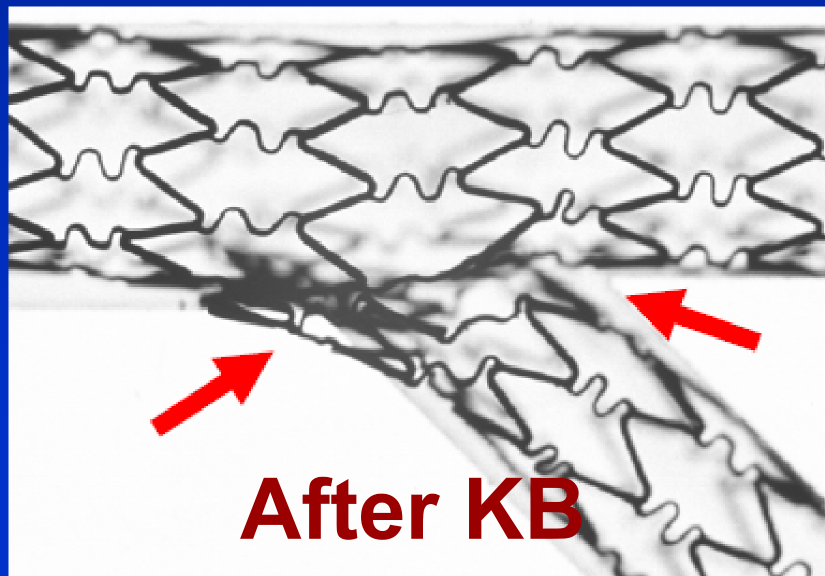
Opening of the side branch ostium

Final kissing balloon inflation

Crush Technique

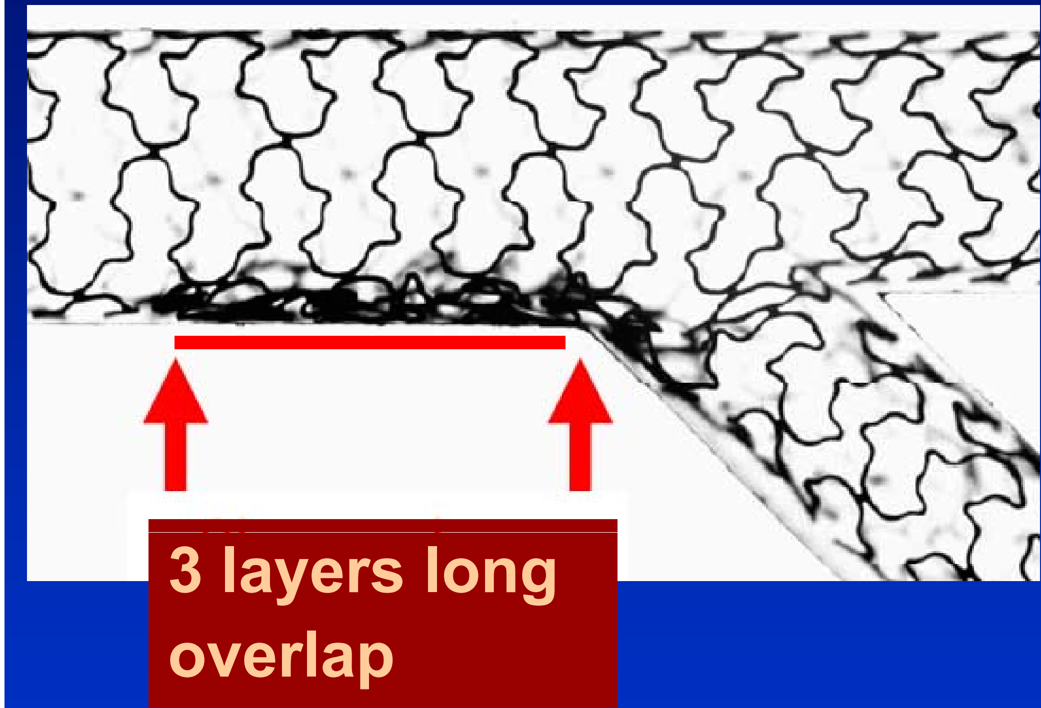
- Safe, quick, limited ischemic time
- Reliably treats the SB
- Always under control
- "Kissing" balloon post-dilation
  - the most difficult, but the most important

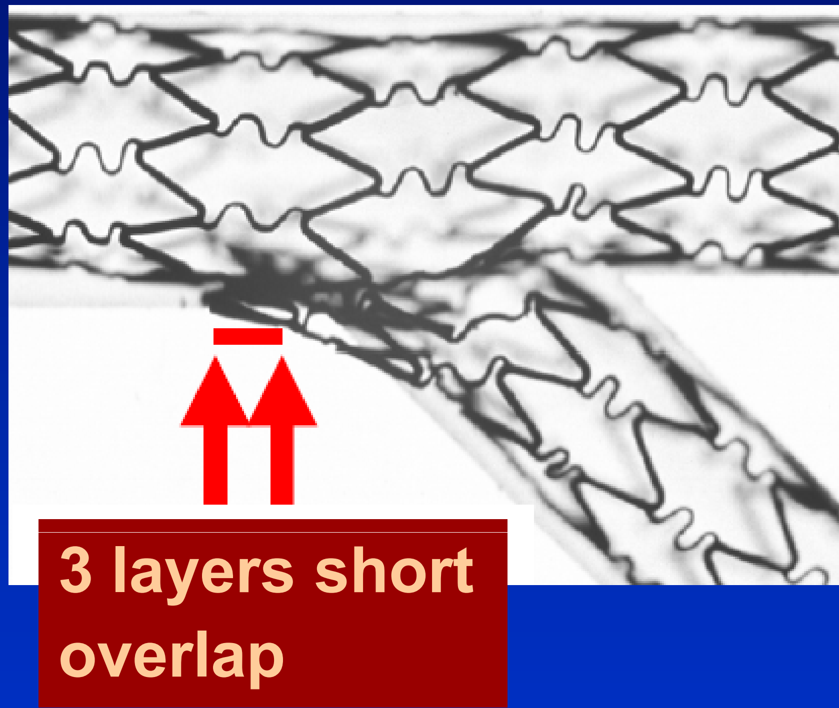




Crush Technique

Limit the length of the 3 layers of overlap





Endothelization with a single layer of DES was better than with overlap. *Finn ACC 05*

Crush Technique

Solution for recrossing

Difficulty wiring crushed sidebranch stent:

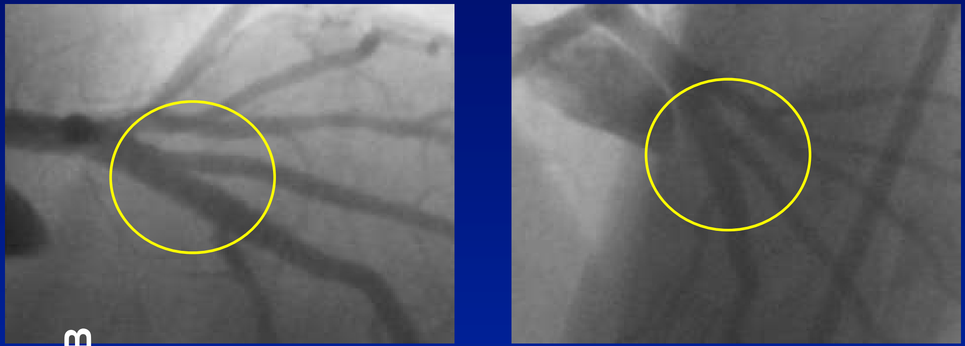
- **Redilate main branch stent at high pressure**
- **Hydrophilic – PT2 or Whisper wires**

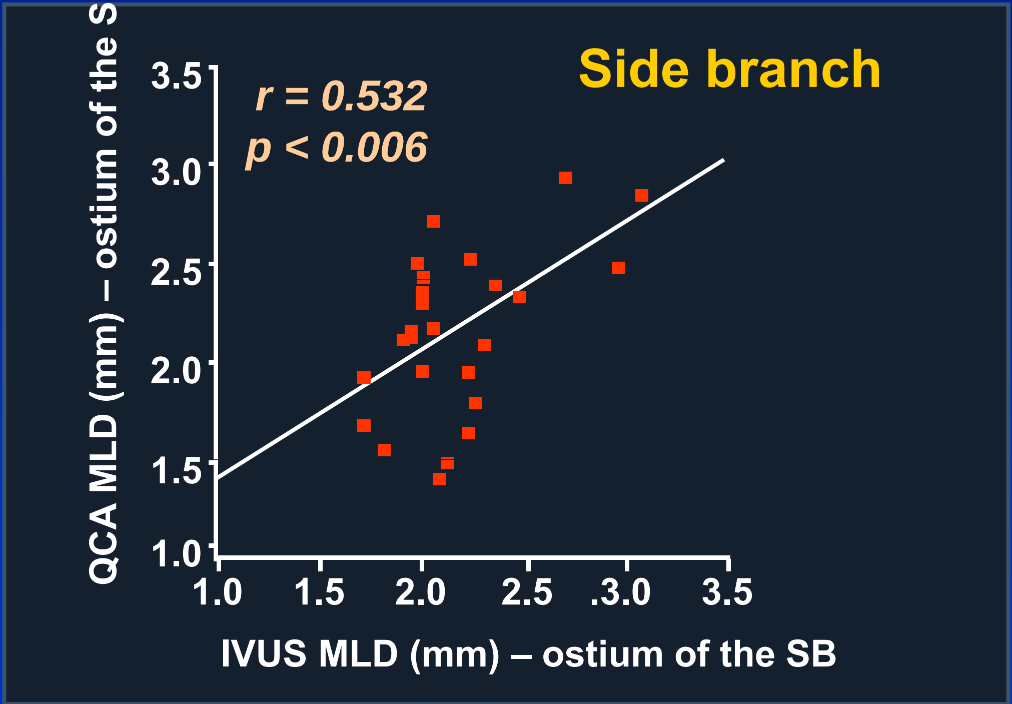
Difficulty crossing:

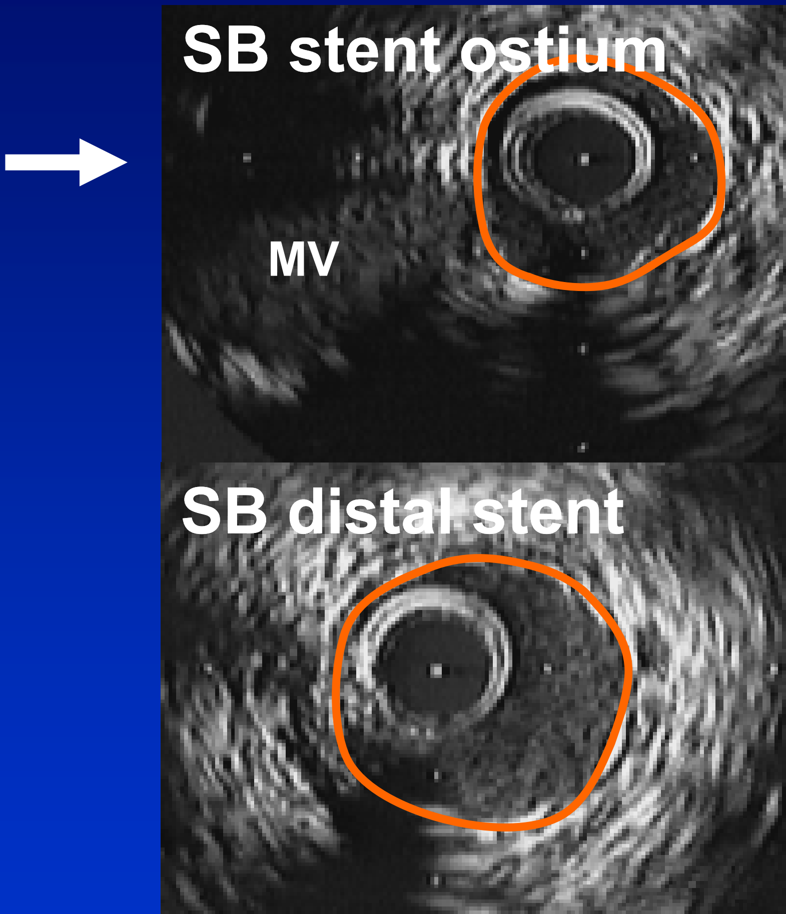
- **1.25 or 1.5 balloon very helpful if difficulty getting back through struts**
- **ACE balloon if 1.25 or 1.5 fails**
- **Anchor balloon technique at distal main stent**
- **If that fails put two wires into side branch**
- **Pass another SB strut**

SB Stent Underexpansion After Crush

Final optimal angiographic result

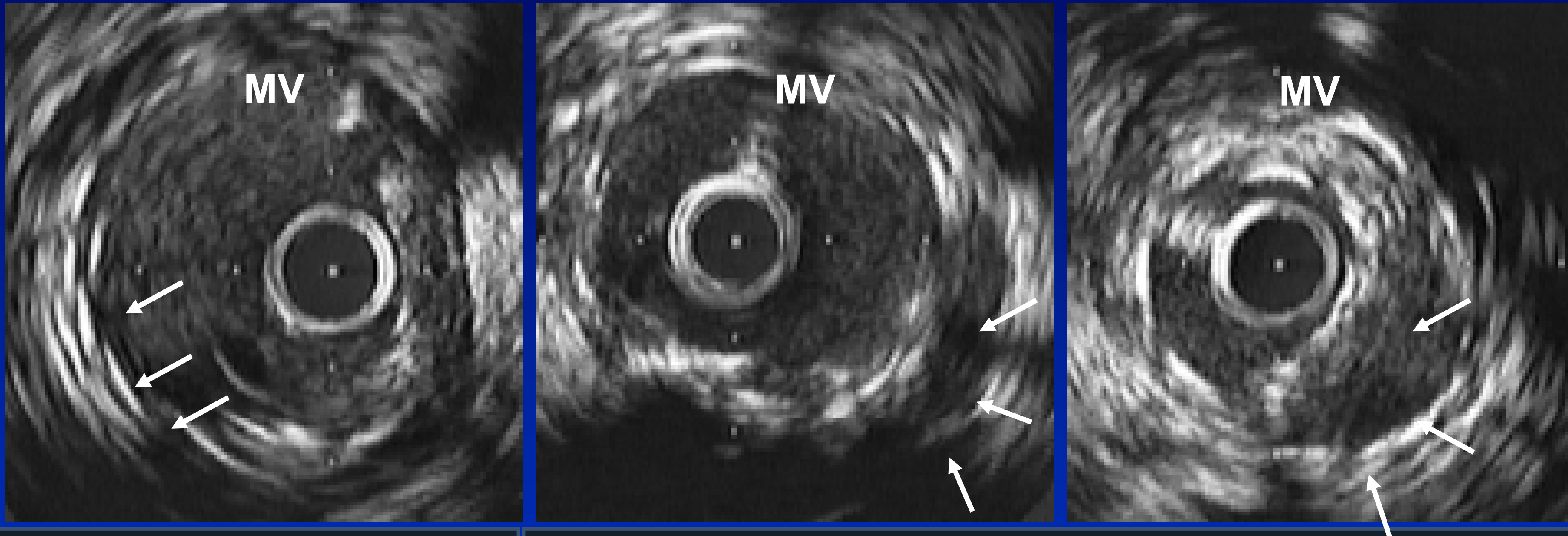






Costa R. *JACC* 2006;46:599

Incomplete "Crush" Apposition



Complete crush (apposition) of the SB stent – arrows indicate the 3 layers of stent struts

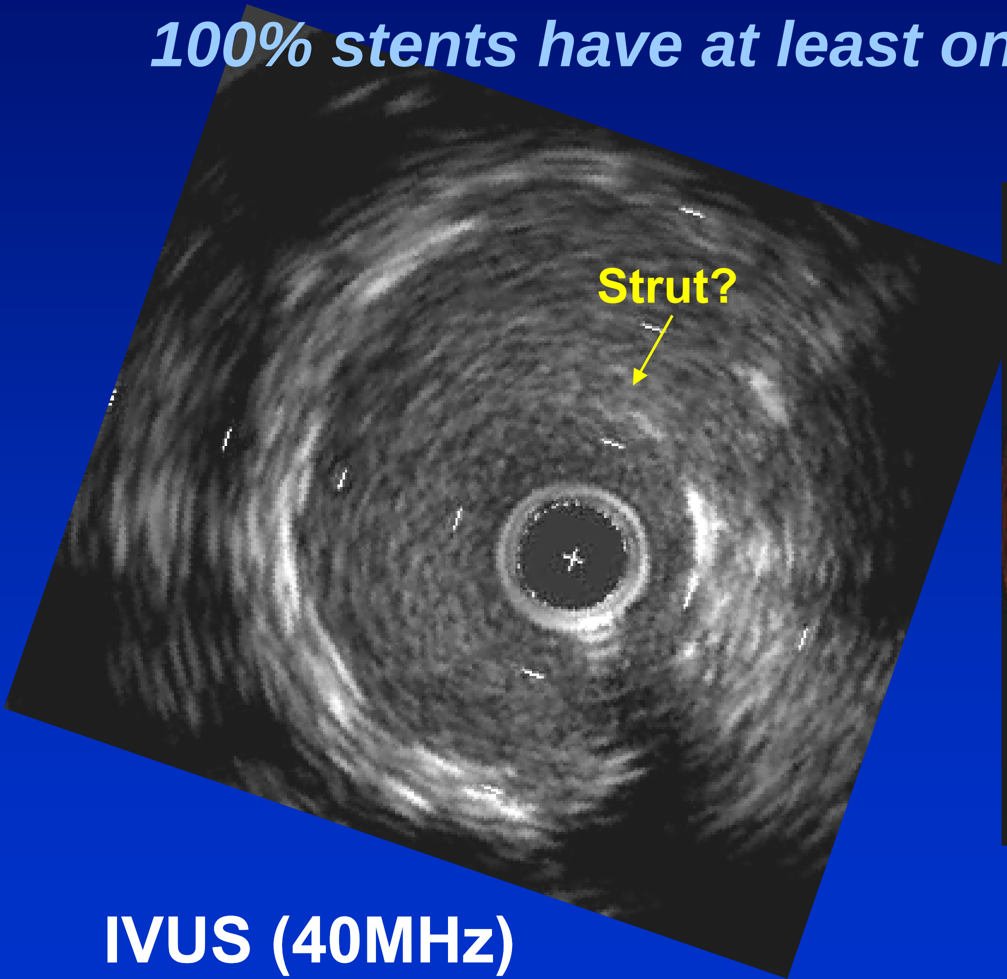
Incomplete crushing – incomplete apposition of the SB or PV stent struts against the MV wall proximal to the carina, found in >60% of non-LM lesions

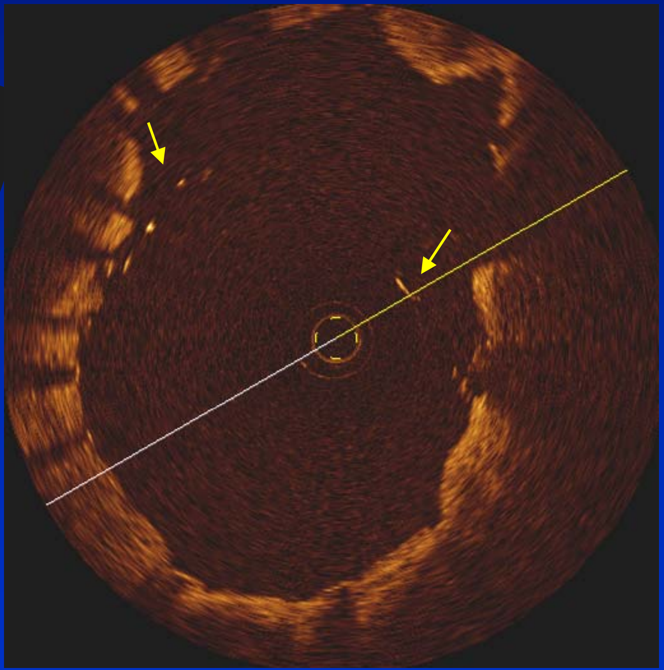
Costa R. *JACC* 2006;46:599

Malapposition at Bifurcation

OCT Evaluation;

100% stents have at least one strut malapposited





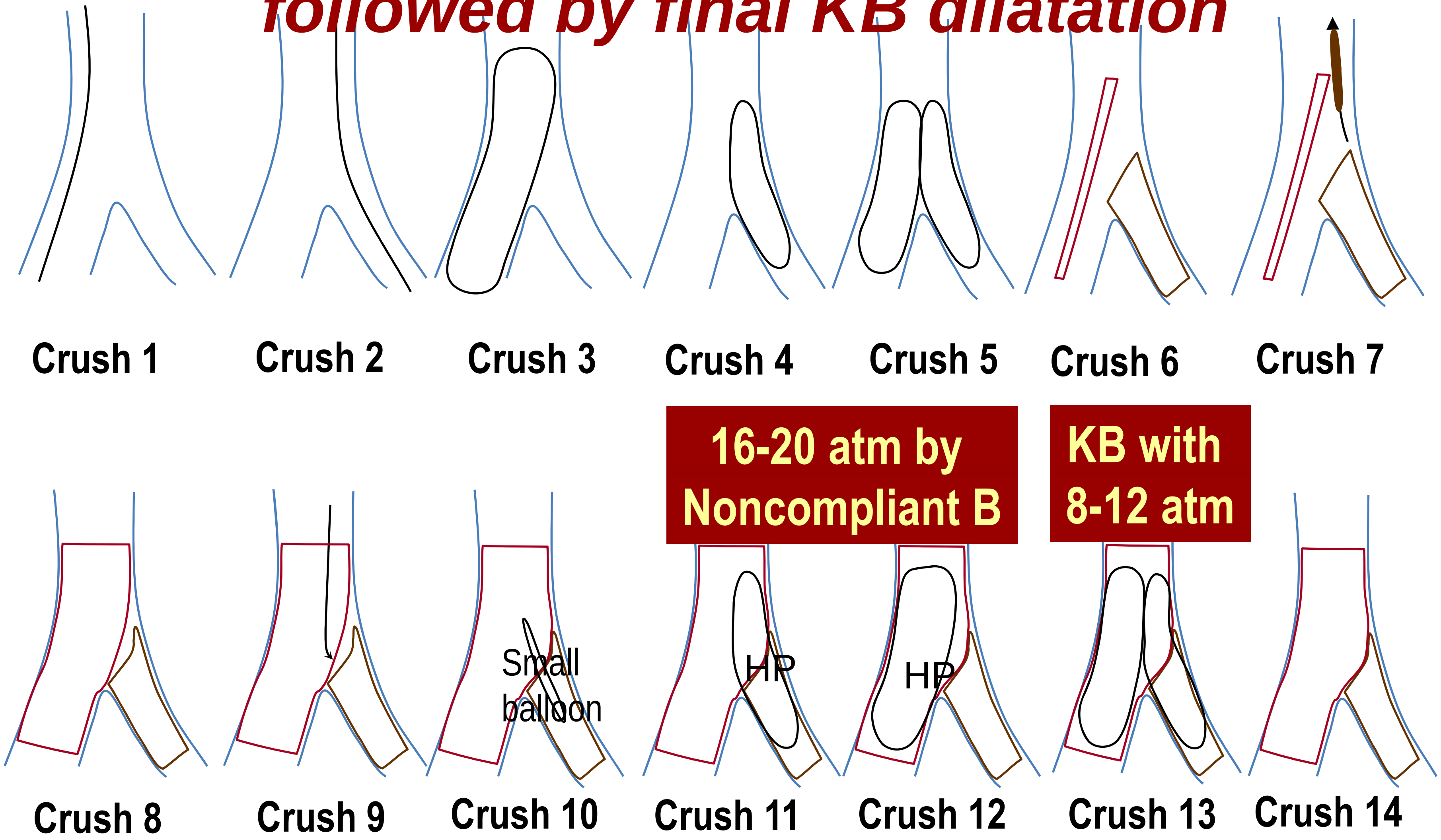
IVUS (40MHz)

OCT

Carlo Di Mario, TCT 2007

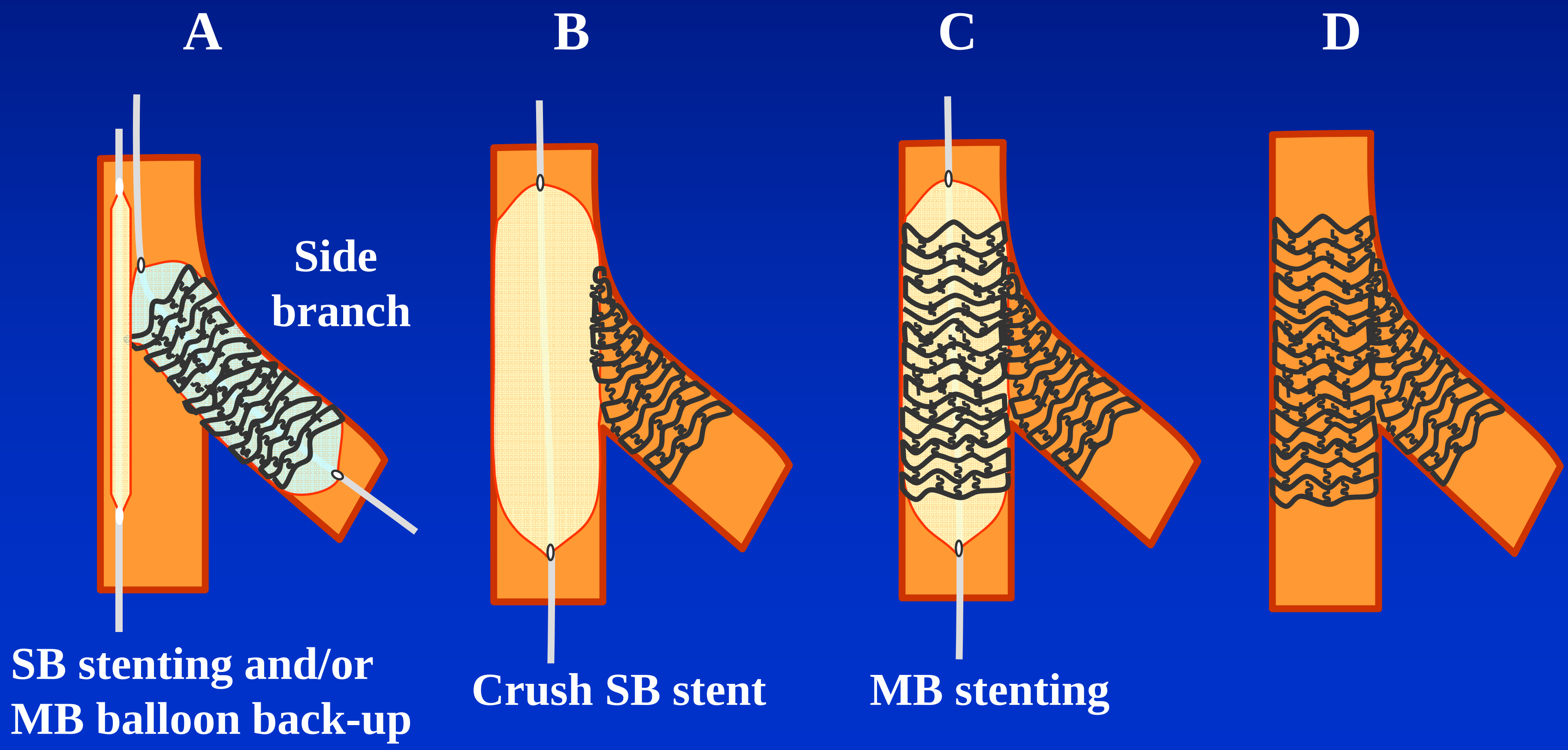
Crush Technique

High pressure sequential balloon dilatation followed by final KB dilatation



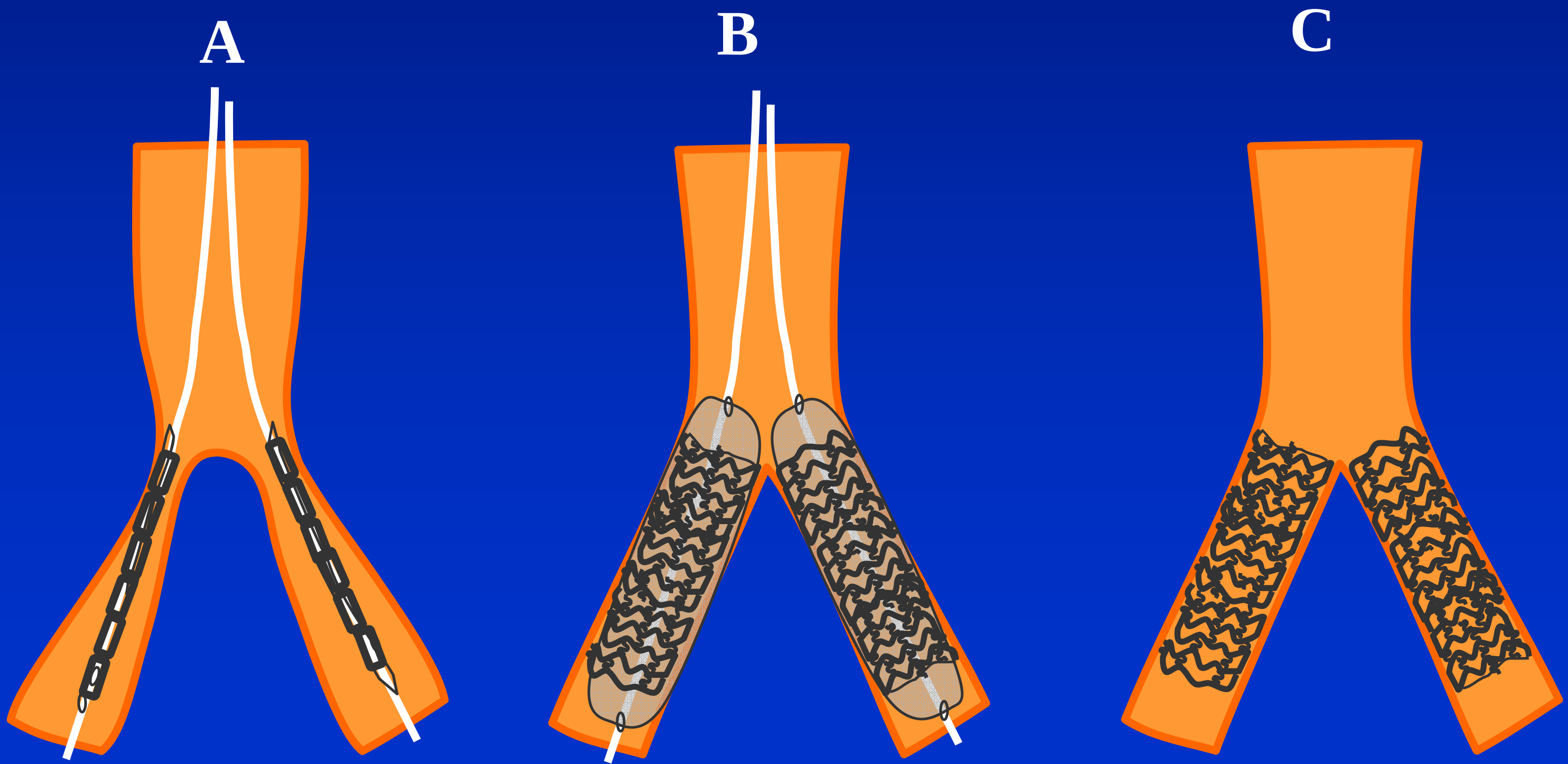
Mini-Crush with balloon

Performed with 6~7Fr guiding catheter



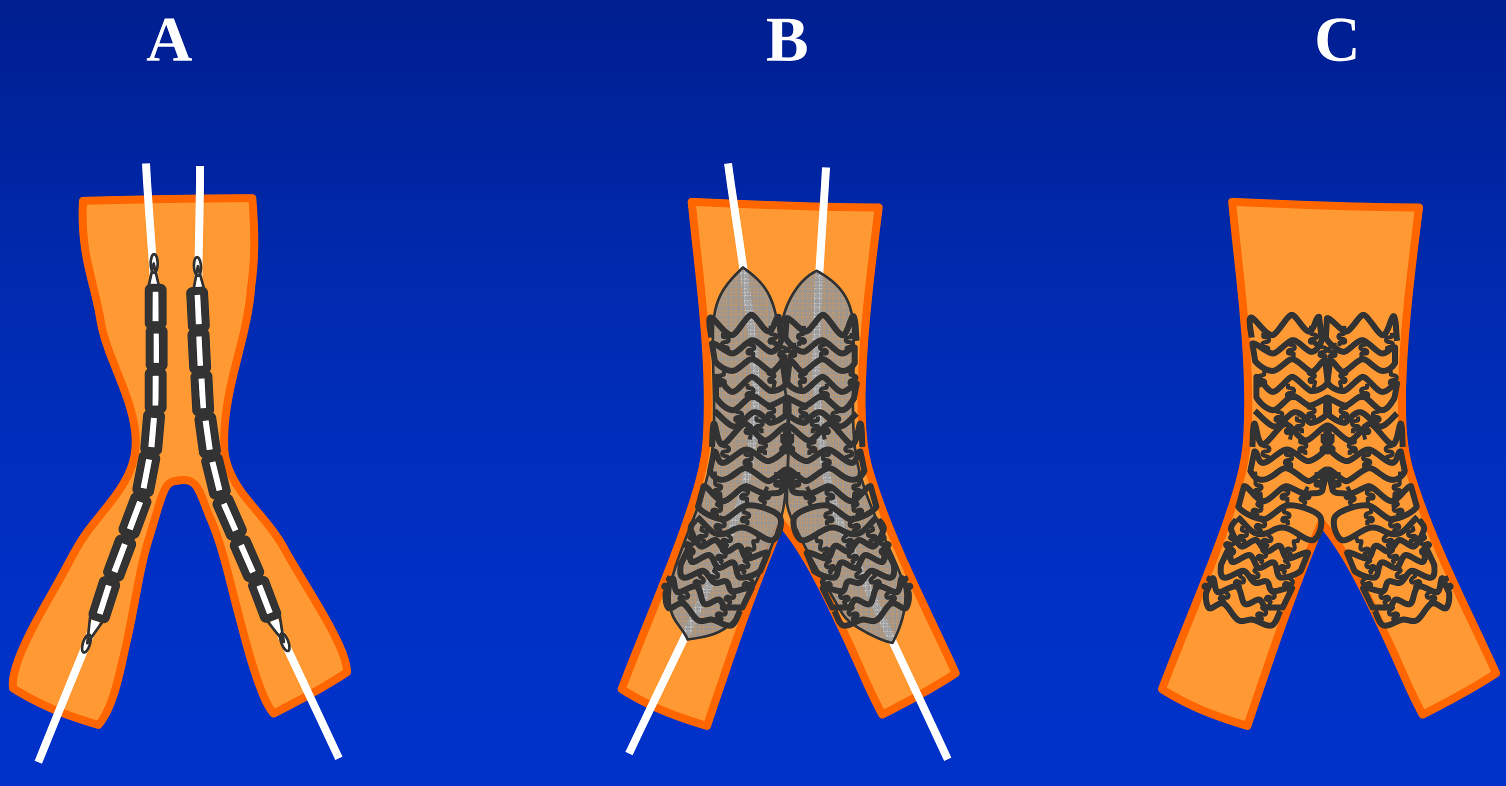
V Stenting

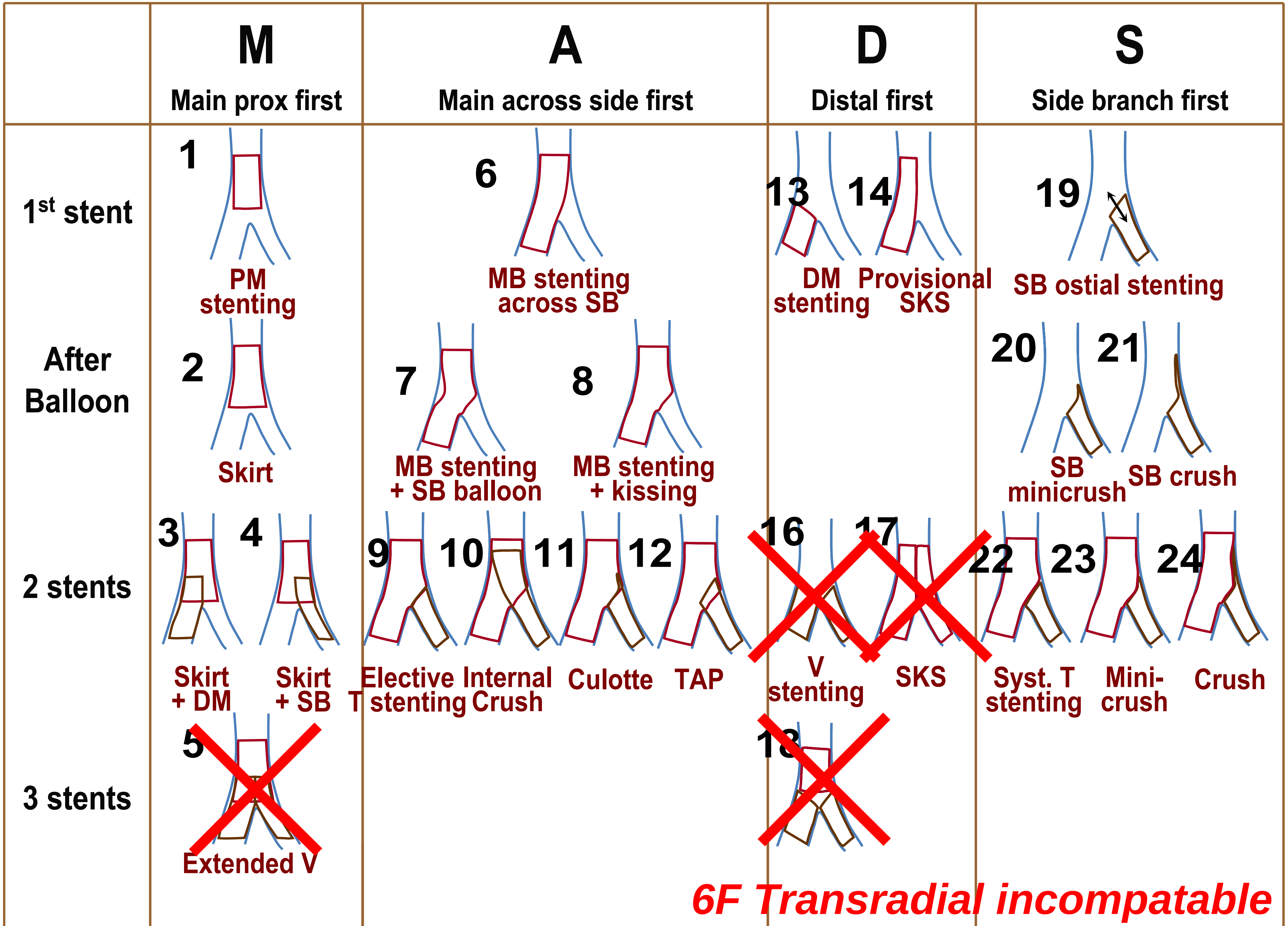
- Bifurcation without stenosis proximal to the bifurcation
- Short LM
- Less angle

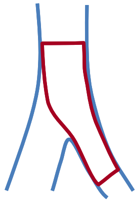
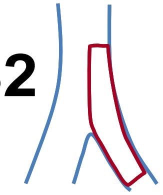
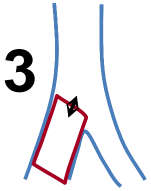
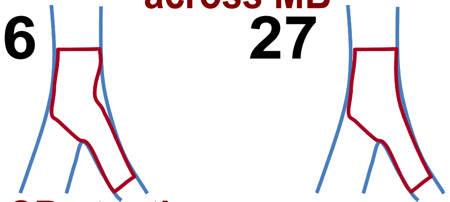
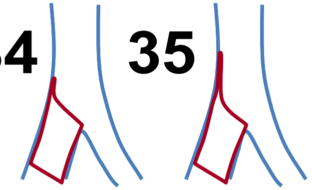
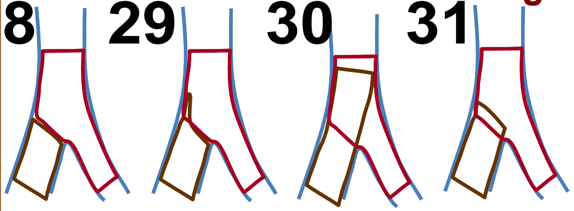
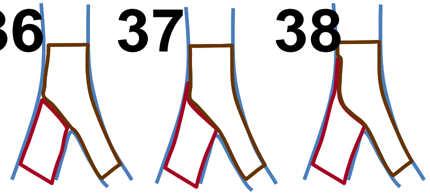


Simultaneous Kissing Stenting

- Large proximal reference
- Bifurcation with stenosis proximal to the bifurcation

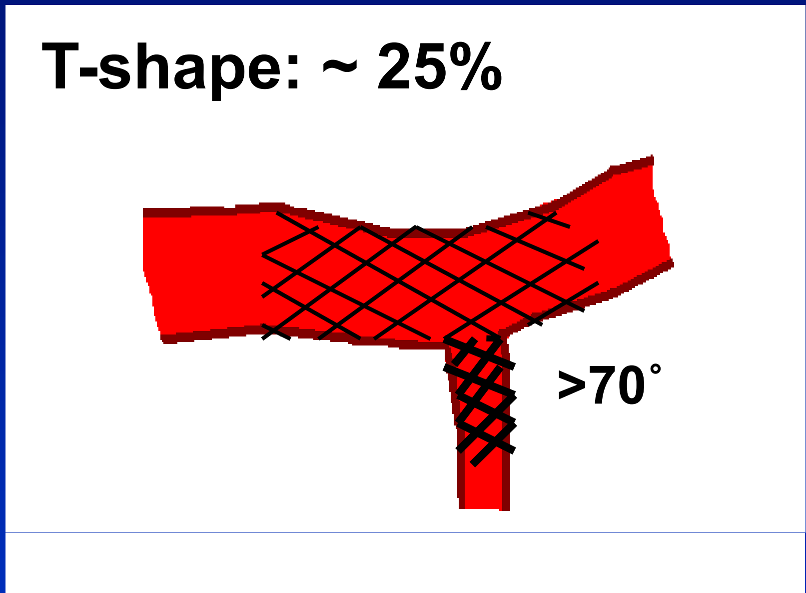


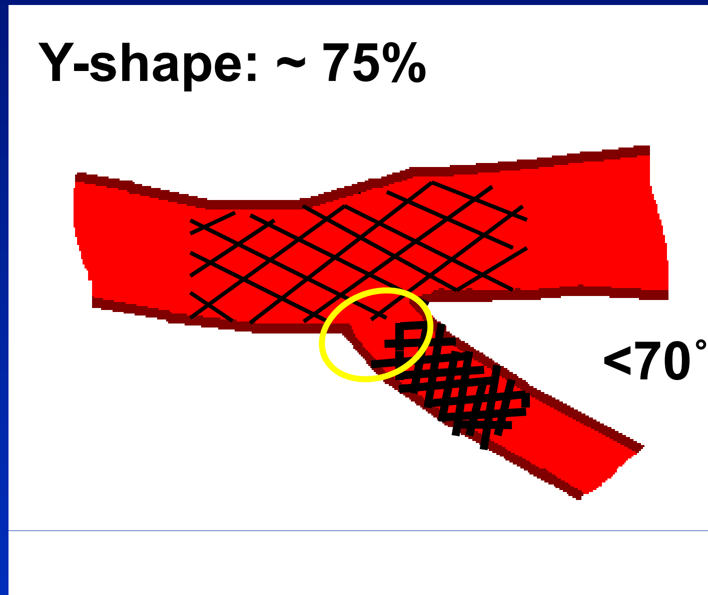

M
Main prox first
A
Main across side first
D
Distal first
S
Side branch first
1st stent
After Balloon
2 stents
3 stents
1
PM stenting
6
MB stenting across SB
13
14
DM stenting
Provisional SKS
19
SB ostial stenting
2
Skirt
7
MB stenting + SB balloon
8
MB stenting + kissing
20
21
SB minicrush
SB crush
3
4
Skirt + DM
Skirt + SB
9
10
11
12
Elective T stenting
Internal Crush
Culotte
TAP
16
17
V stenting
SKS
22
23
24
Syst. T stenting
Mini-crush
Crush
5
Extended V
18
6F Transradial incompatable

	M Main prox first	A Main across side first	D Distal first	S Side branch first
1st stent		25  Inv. SB stenting across MB	32  Inv. provisional SKS	33  DM ostial stenting
After Balloon		26 27  26: MB to SB stenting + DM balloon; 27: MB to SB stenting + kissing		34 35  34: DM minicrush; 35: DM crush
2 stents		28 29 30 31  28: Inv. elective T stenting; 29: Inv. internal crush; 30: Inv. culotte; 31: Inv. TAP		36 37 38  36: Inv. syst. T stenting; 37: Inv. minicrush; 38: Inv. crush

Choice of Two Stenting Technology

Based on Angulation



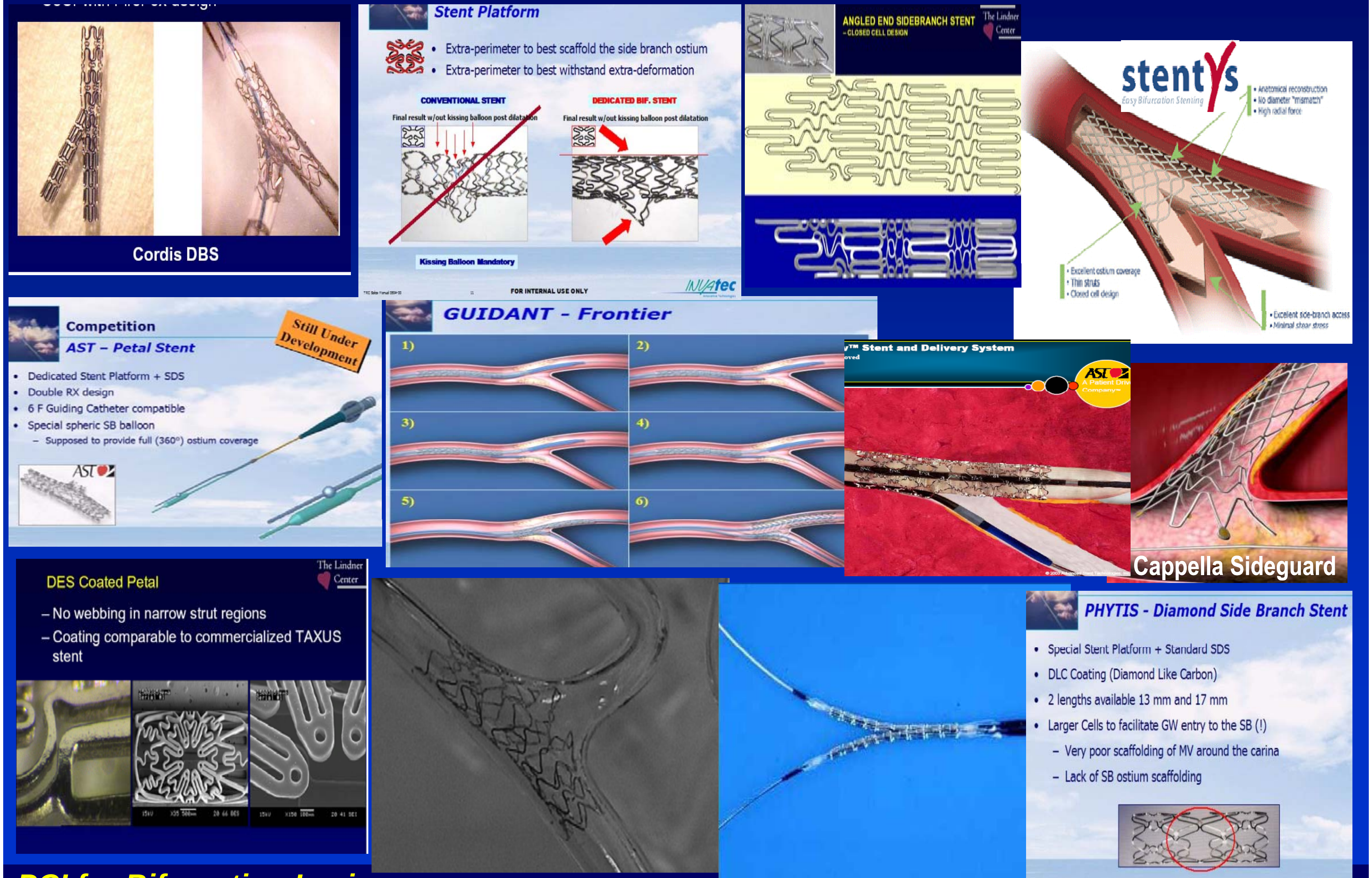


Minimize crushed strut
→ T-stenting

Don't miss SB ostium
→ Crush or Cullotte

Mini-Crush Can Work All Angulations

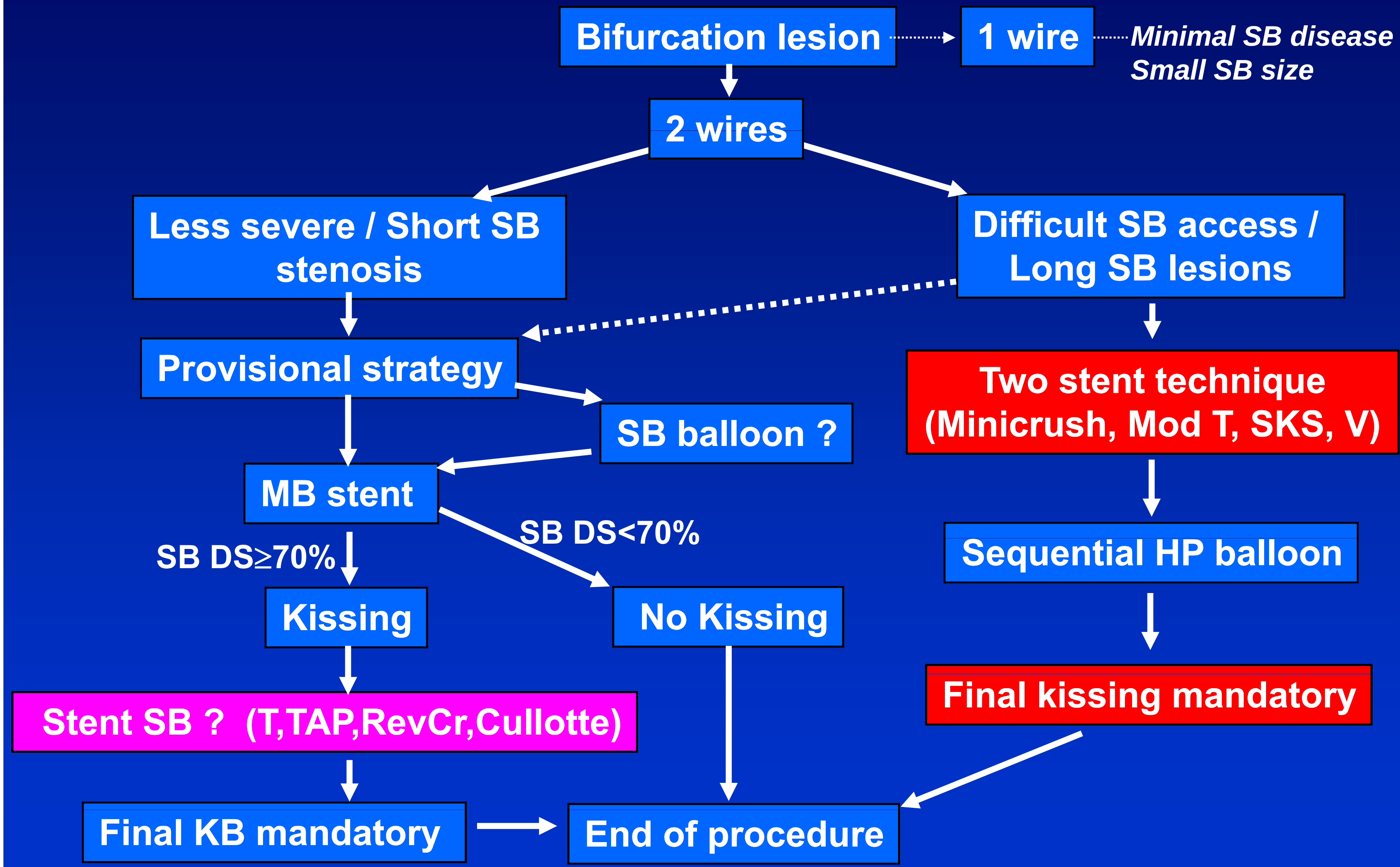
Dedicated Bifurcations Stents



Guidelines for Bifurcation PCI

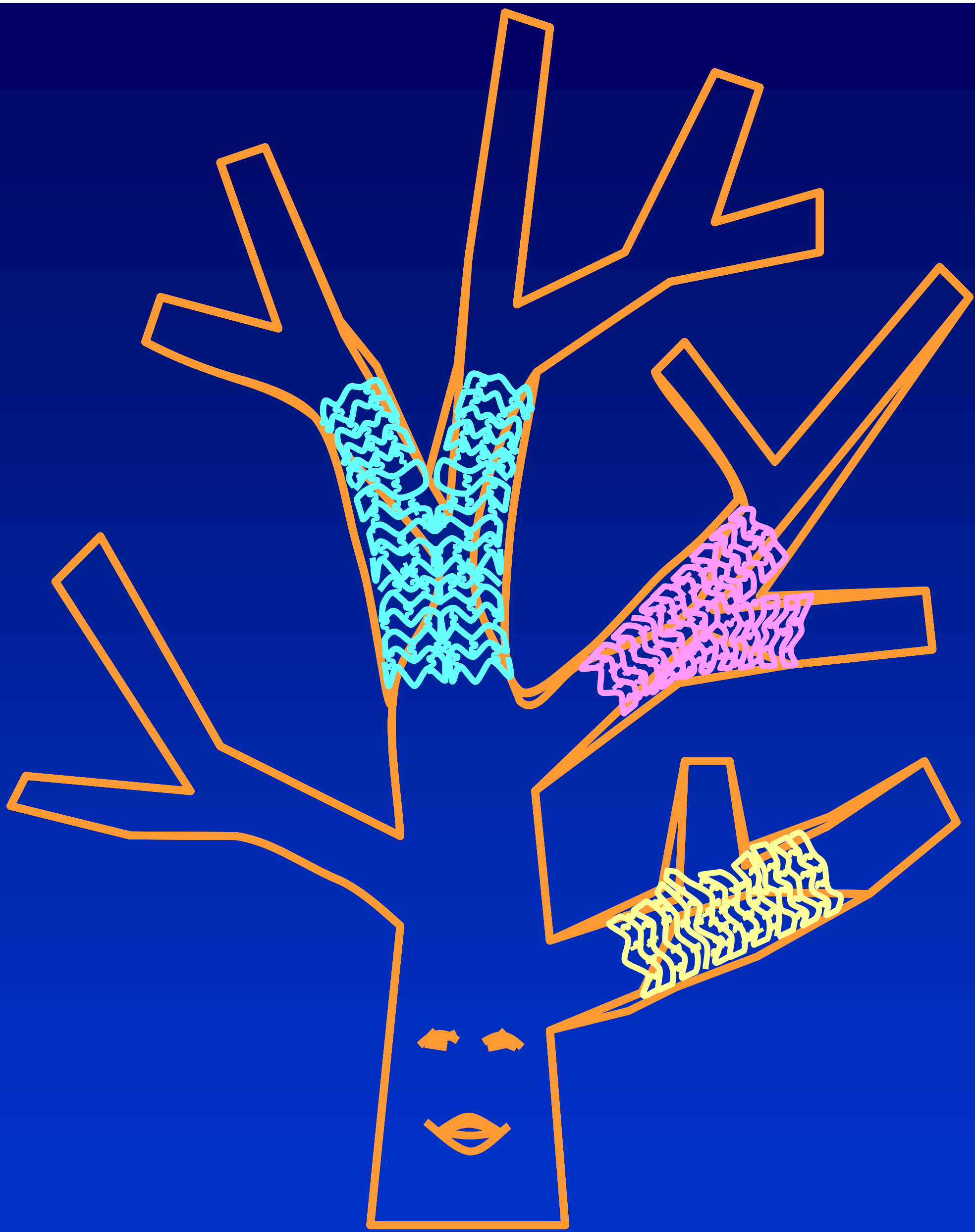
- Assess the patient
  - Clinical presentation, LV EF, Age, Viability …
- Assess the lesion
  - Distribution of plaque
  - Angulation
  - Importance of SB
- Plan your strategy
  - Think several moves ahead
  - Have a backup

Selection of Stenting Strategy



PCI for Bifurcation

- DES implantation has dramatically improved long-term outcome of the main vessel in the bifurcation lesions.
- There is no perfect solution for bifurcation stenting with DES.
- Until now, no statement can be made regarding the most appropriate technique with DES for bifurcation lesions.
- Therefore, treatment decision should depends on each patient and each lesion.



Thanks for your time