# Left Main Bifurcation

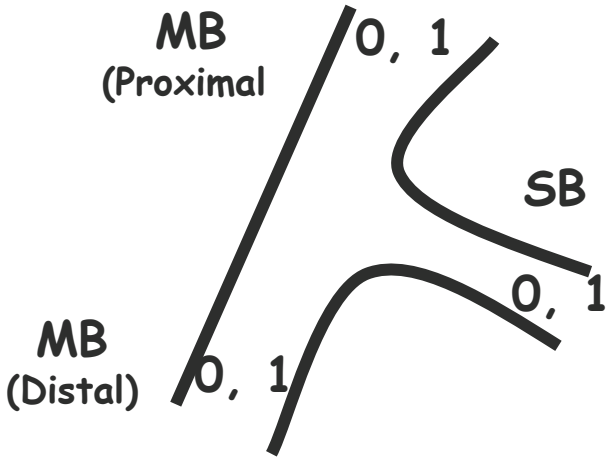
*Cors at the Shore*
*June 23-24, 2023*

*Manish A. Parikh, MD, FACC, FSCAI*
*Chief, Division of Cardiology*
*Associate Professor of Medicine*
*New York Presbyterian-Brooklyn Methodist Hospital*
*Weill Cornell Medicine*

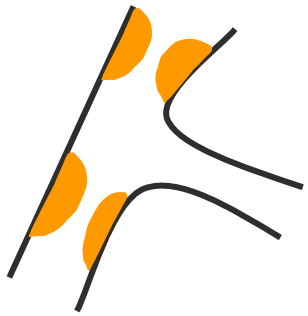
# Financial Disclosures

- SB:  Abbott Vascular, Medtronic, BSc
- Advisory Boards:  Abbott Vascular, Medtronic, BSc

# Medina Classification




1,1,1



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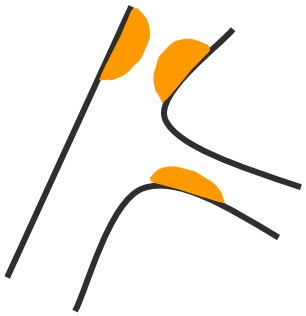
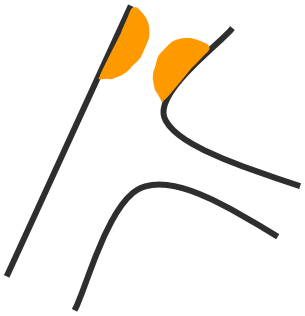


1,0,1

0,1,1



1,0,0

0,1,0

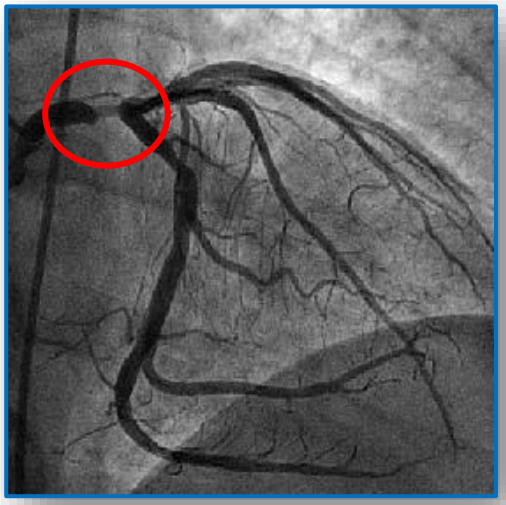
0,0,1

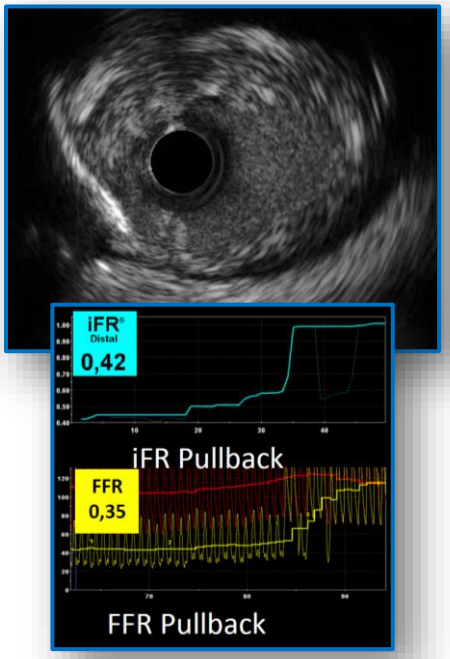
Medina et al. Rev. Esp. Cardiol 2006; 59(2): 183-4

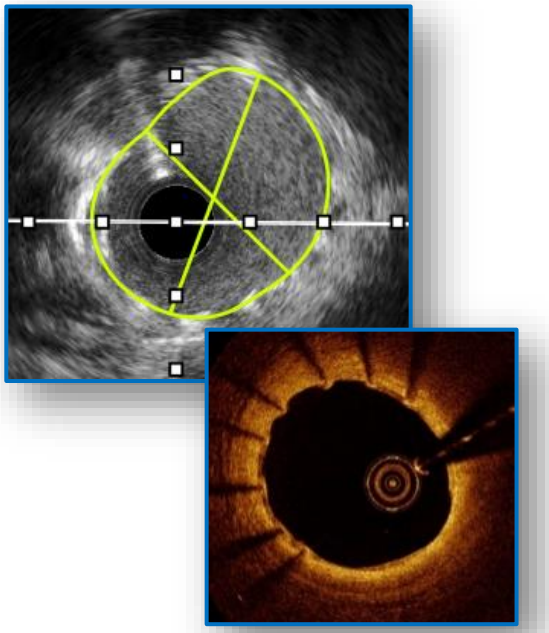
DRIVING THE FUTURE of PRECISION MEDICINE

# DIAGNOSIS INTERVENTION

## Assessment Guidance Optimization





EDITORIAL

# Imaging and Physiology Get Along in the Left Main Coronary Artey Disease

## The Case for Intravascular Ultrasound and Instantaneous Wave-Free Ratio

Jose M. de la Torre Hernandez, MD, PhD

Circ Cardiovasc Interv.
2021;14(6):e010887

## Left Main Coronary Artery intermediate stenosis

**IVUS**

< 4.5 mm² | 4.5 – 6 mm² | > 6 mm²

**FFR** <0.8 ≥0.8 | **iFR** ≤0.89 >0.89

→ Revascularization / Deferral

**FFR** <0.8 ≥0.8 | **iFR** ≤0.89 >0.89

Discordant FFR / iFR values in LAD / LCx:
**IVUS** in LMCA-LAD + LMCA-LCx

→ Revascularization / Deferral

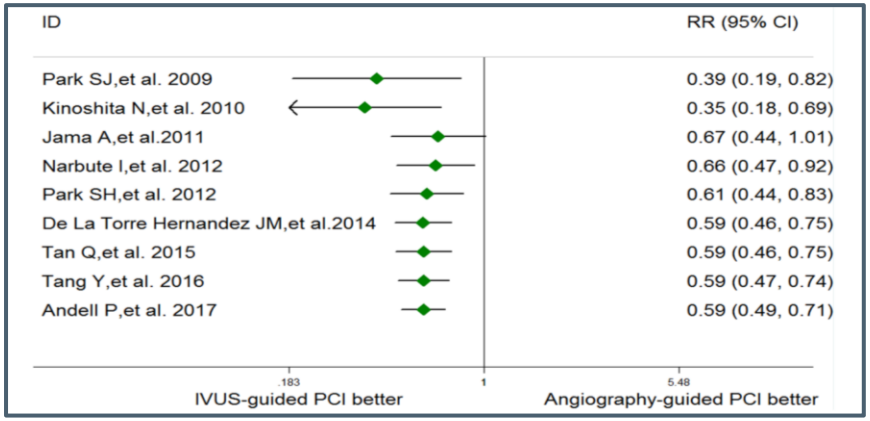
**Pro-IVUS**
- Mid-shaft LMCA lesion
- Distal LMCA lesion
- Lesions in LAD / LCx
- PCI-eligible if significant LMCA lesion

**Always put IVUS/FFR/iFR data in context:**
- Symptoms
- Electrocardiographic / echocardiographic findings
- LMCA lesion complexity
- Extension of coronary artery disease
- PCI / CABG eligible patient
- Patient profile (age, frailty, bleeding risk, comorbidities,…)

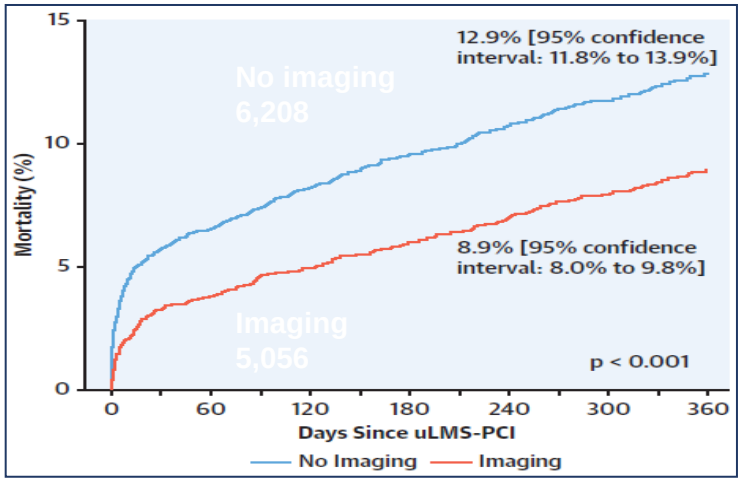
**Pro-FFR / (iFR)**
- Ostial LMCA lesion
- Ostial LAD / LCx involvement
- Akinesia (scar) LAD / LCx

**(pro-iFR)**
- Lesions in LAD / LCx
- Severe LV hypertrophy

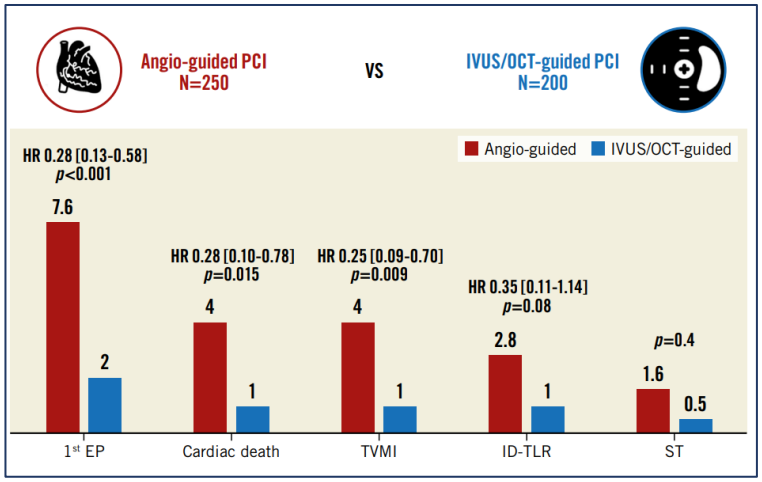
# Registries show consistent benefits for IVUS guided LM PCI




Ye Y, et al. PLoS ONE 12(6): e0179756.



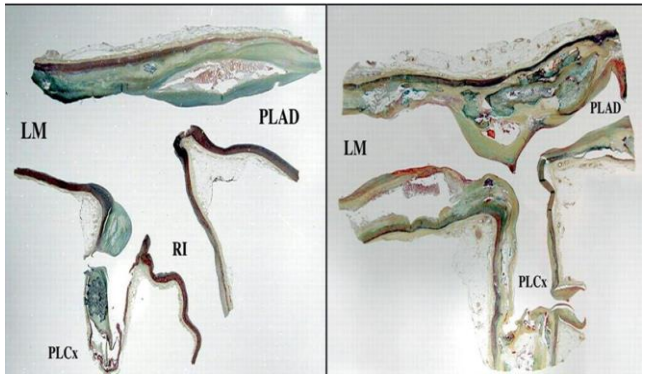

Kinnaird T et al. JACC intv 2020



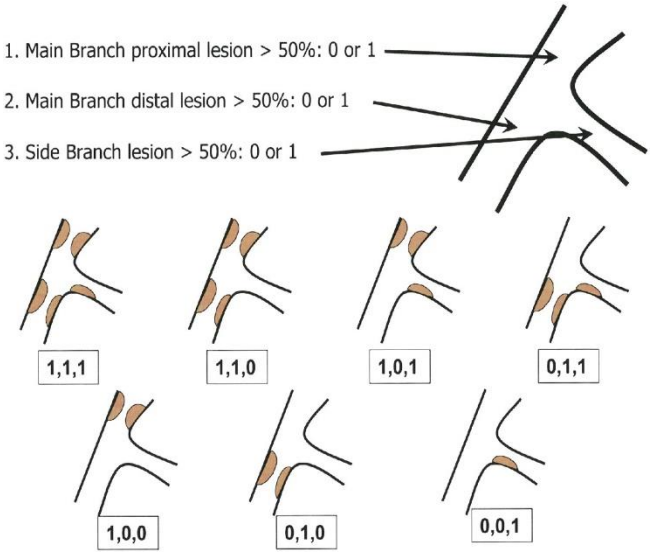

Tarantini G et al, Eurointervention 2022

# TIP # 1- Pre Procedure Plan

- Decide Initial and Bailout Strategy
- Left Main Morphology and disease distribution
- Need for Hemodynamic support

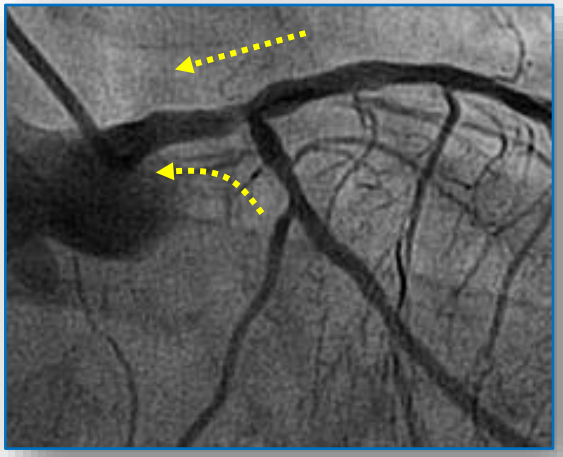


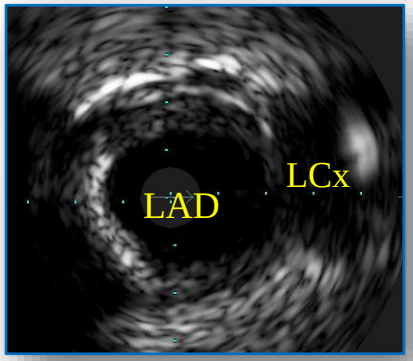

- Pure Ostial – 15%
- Mid Shaft – 20%
- Ostial & Shaft – 15%
- Bifurcation – 50%

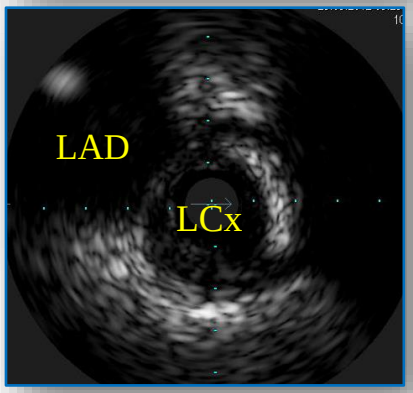


# Assessment of LAD and LCx ostium in distal LM disease

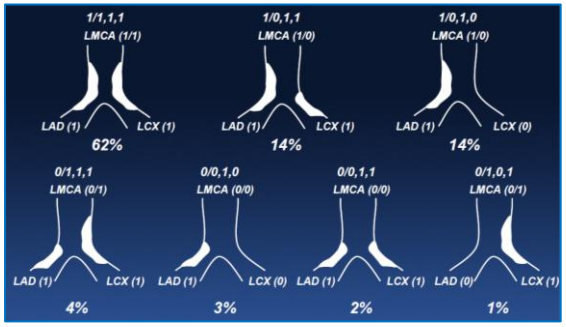
ANGIO






| | +PV | -PV |
|---|---|---|
| ***Ostial LAD*** | | |
| Plaque burden > 70% | ***41%*** | ***87%*** |
| MLA < 4 mm$^2$ | ***47%*** | ***83%*** |
| ***Ostial LCx*** | | |
| Plaque burden > 70% | ***14%*** | ***94%*** |
| MLA < 4 mm$^2$ | ***52%*** | ***75%*** |




Oviedo et al. Circ Cardiovasc Interv. 2010;3:105-12

Preference for provisional stenting

-Small LCx

-No LCx disease (< 50%) (1,0,0) (1,1,0)

-Lesion in ostial LCx extending < 5 mm

-Wide angle LAD / LCx

-No significant ostial LCx disease by IVUS (MLA > 4 $mm^2$, no calcified nodule, no layered plaque)

## Preference for 2-stents technique

No small LCx with any of the following:

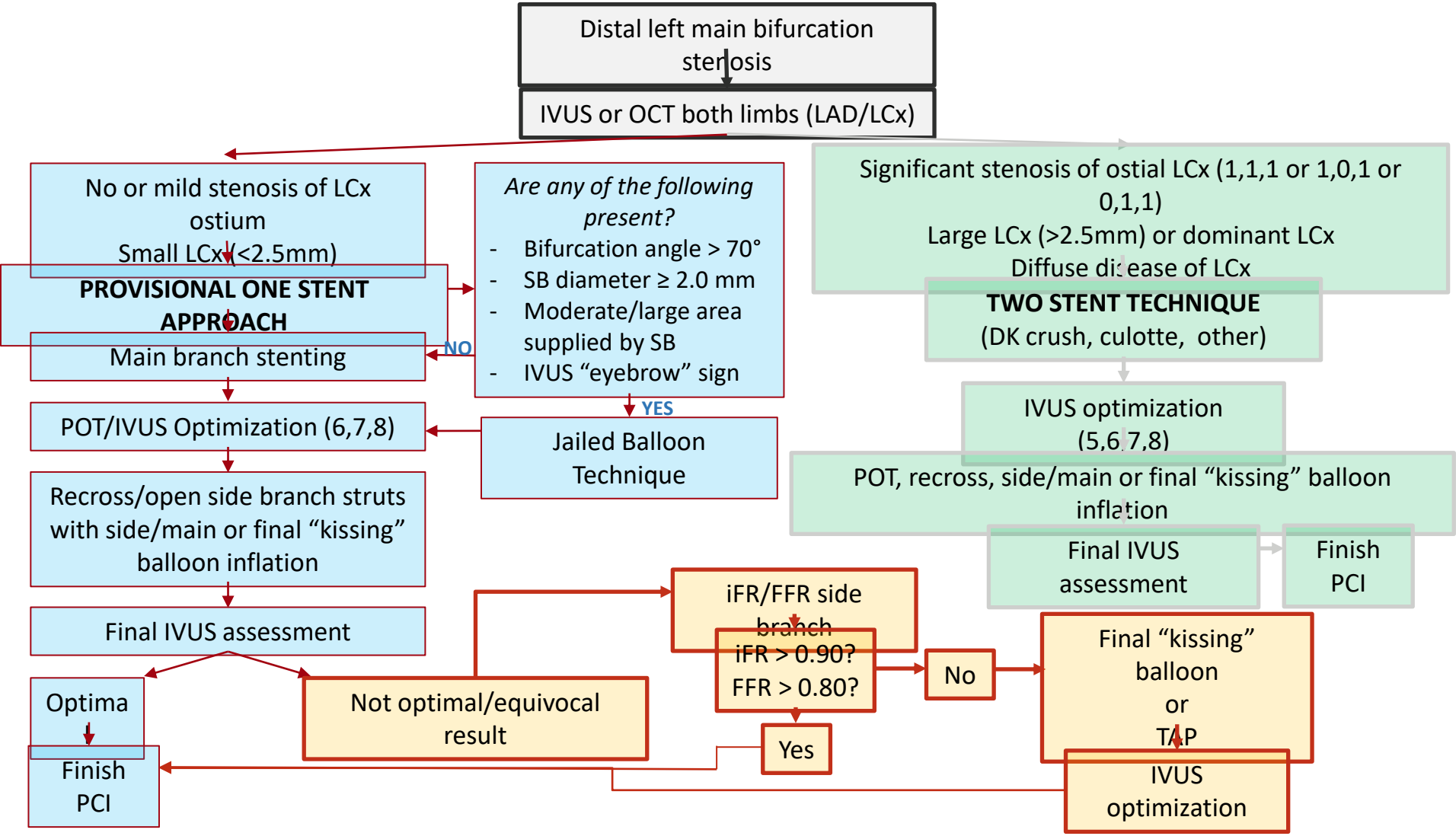
-Significant and long (> 5 mm) lesion in ostial LCx (1,1,1) (0,1,1) (1,0,1)

-Complex lesion in ostial LCx

-Narrow angle LAD / LCx

-Significant ostial LCx disease by IVUS

(MLA < 4 mm2 , calcified nodule, layered plaque)


Distal left main bifurcation stenosis
IVUS or OCT both limbs (LAD/LCx)
No or mild stenosis of LCx ostium
Small LCx (<2.5mm)
PROVISIONAL ONE STENT APPROACH
Main branch stenting
POT/IVUS Optimization (6,7,8)
Recross/open side branch struts with side/main or final "kissing" balloon inflation
Final IVUS assessment
Optima
Finish PCI
Not optimal/equivocal result
Are any of the following present?
- Bifurcation angle > 70°
- SB diameter ≥ 2.0 mm
- Moderate/large area supplied by SB
- IVUS "eyebrow" sign
NO
YES
Jailed Balloon Technique
iFR/FFR side branch
iFR > 0.90?
FFR > 0.80?
No
Yes
Final "kissing" balloon or TAP
IVUS optimization
Significant stenosis of ostial LCx (1,1,1 or 1,0,1 or 0,1,1)
Large LCx (>2.5mm) or dominant LCx
Diffuse disease of LCx
TWO STENT TECHNIQUE
(DK crush, culotte, other)
IVUS optimization (5,6,7,8)
POT, recross, side/main or final "kissing" balloon inflation
Final IVUS assessment
Finish PCI

# Indication for Hemodynamic Support During PCI

**- Left main: bifurcation with EF<35%**

**- ostial or mid LM severe calcification with EF<35%**

**- LM in the setting of ACS and EF<35%**

- severe 3V CAD with EF<35%

- last remaining conduit

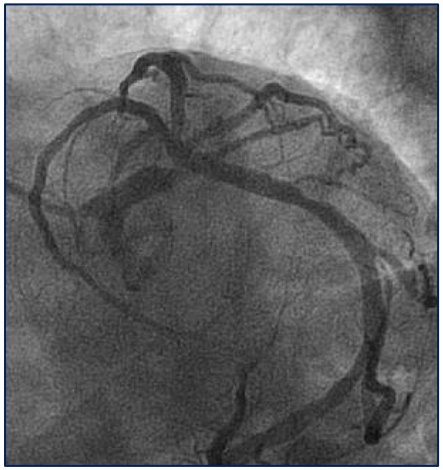
- PCI of vessel supplying large territory in pts with poor recovery reserve (AS, HOCM, severe MR etc)

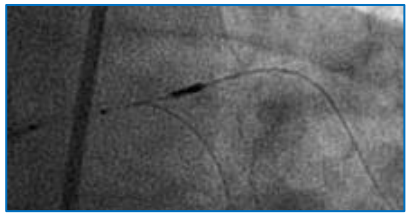
- Baseline relative hypotension (SBP<100mmHg)

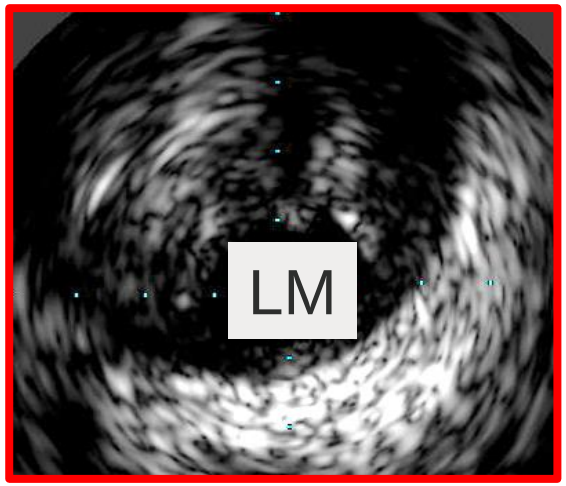
- Cardiogenic Shock

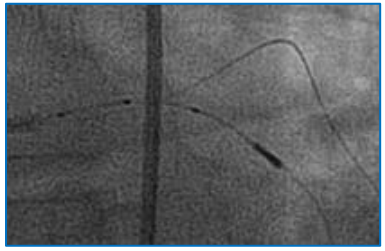
-STEMI or high risk NSTEMI, age <75, lactate>3mmol/l, HR>100/min

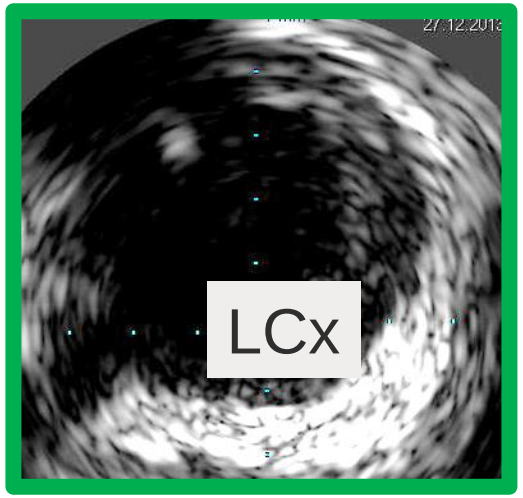
# Left Main-One Stent Technique or Two?







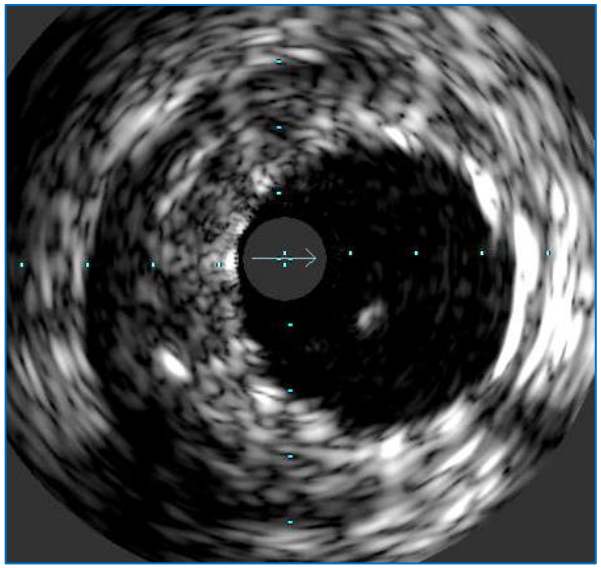



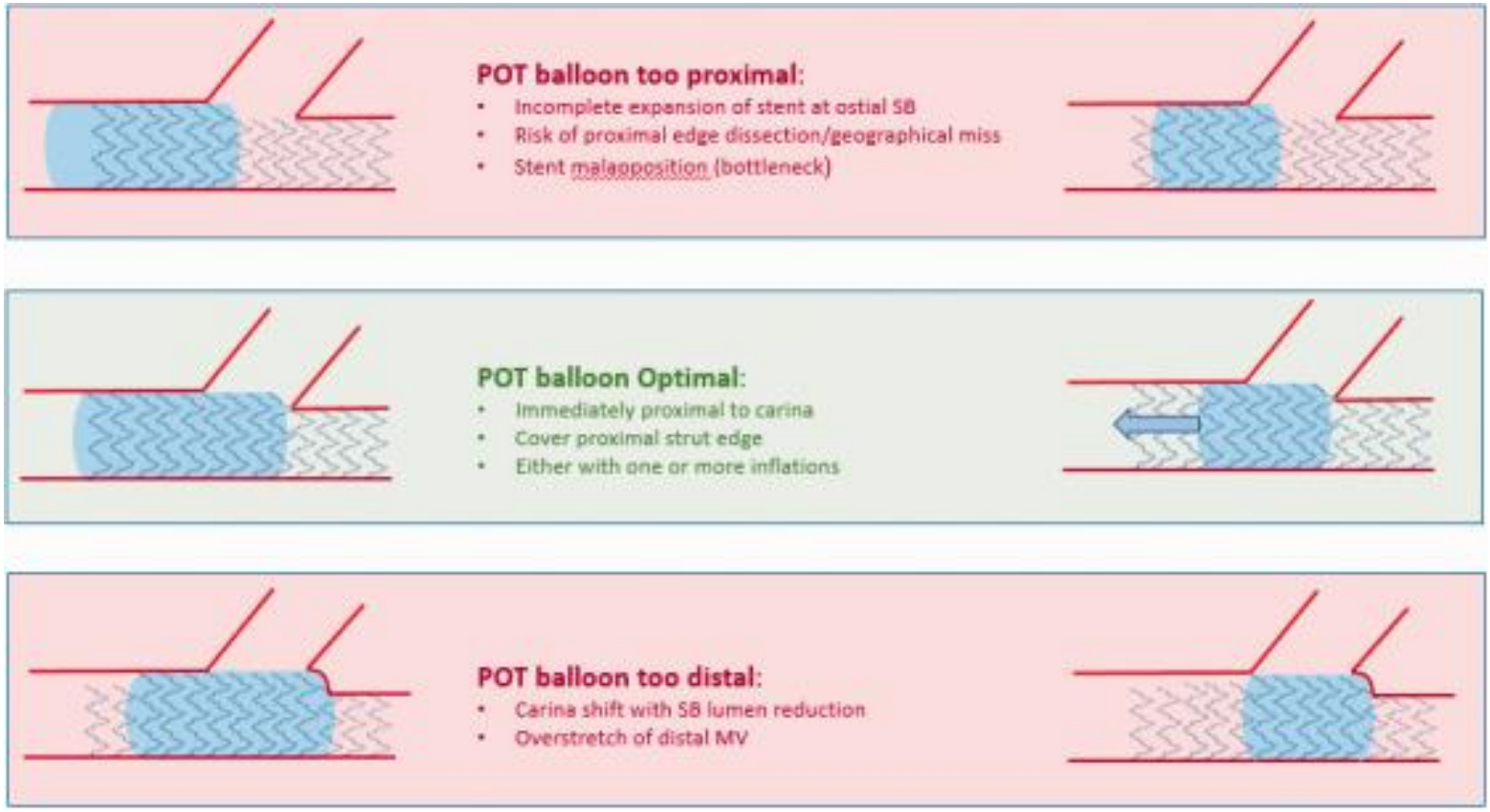
# Provisional One Stent Technique

DES 4 / 16
LM - LAD

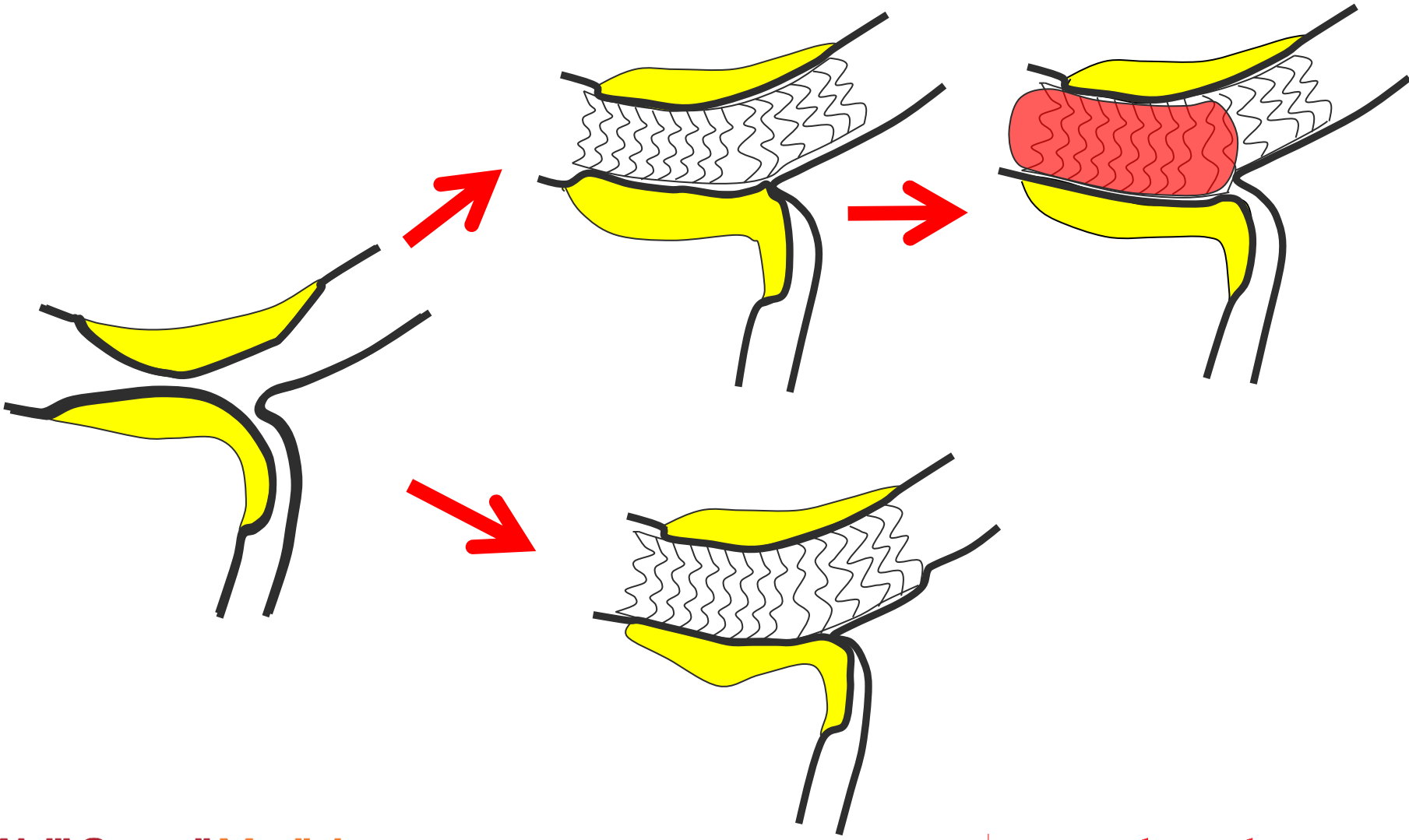
POT with 5 mm



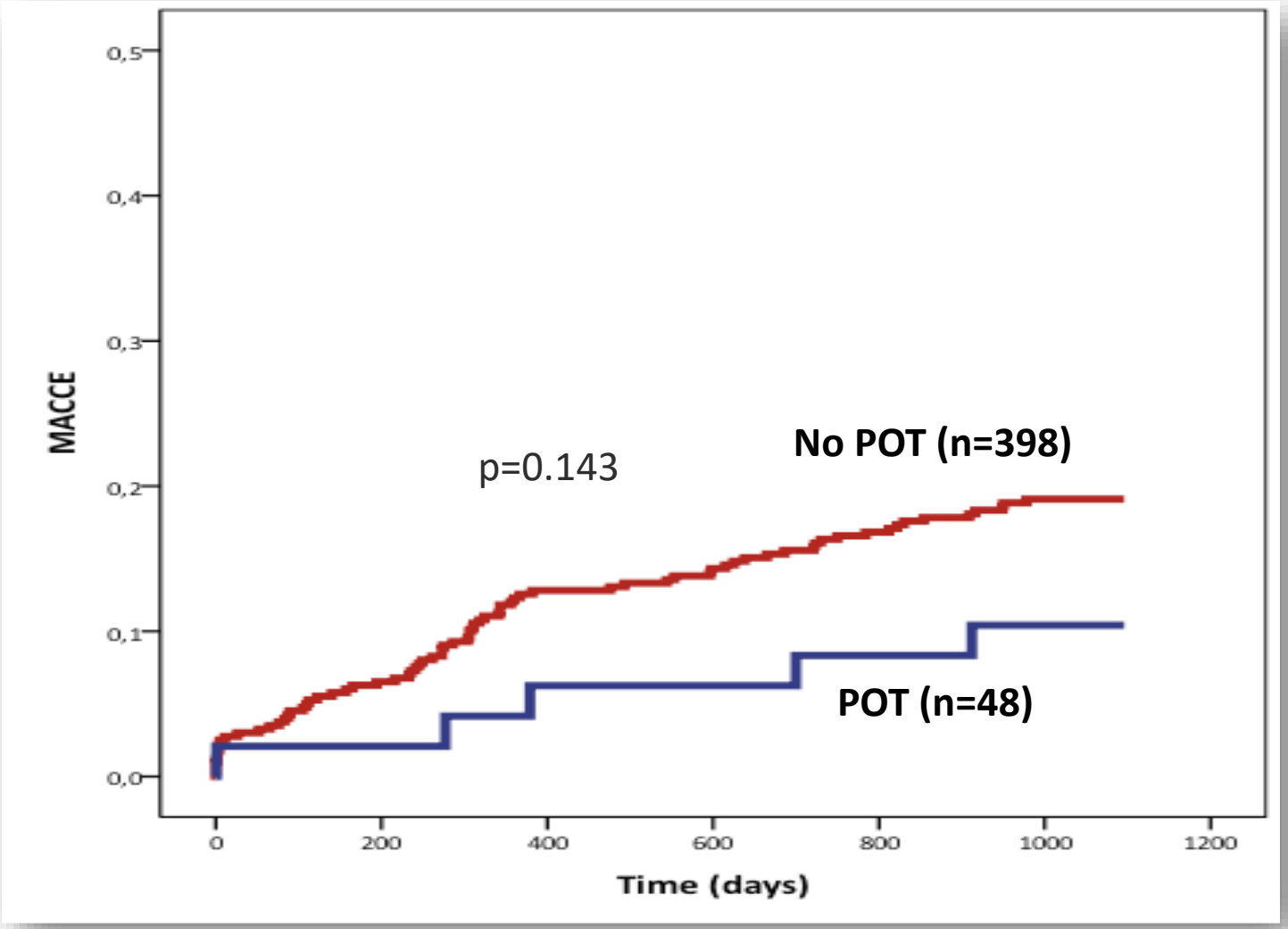
# Proximal Optimization Technique
# POT



# Role of Proximal Optimization Technique (POT)



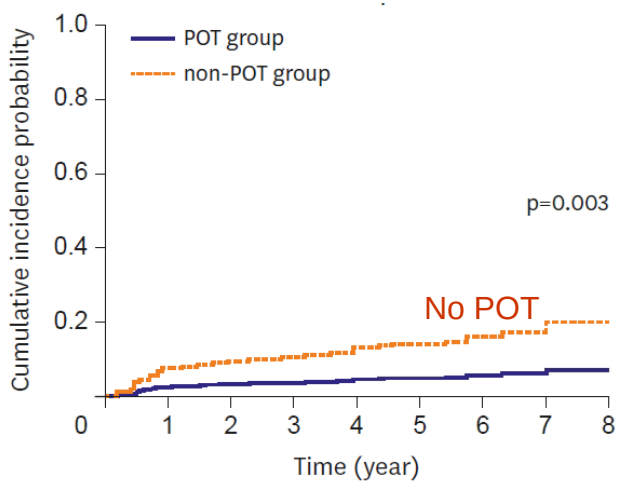
# Role of POT



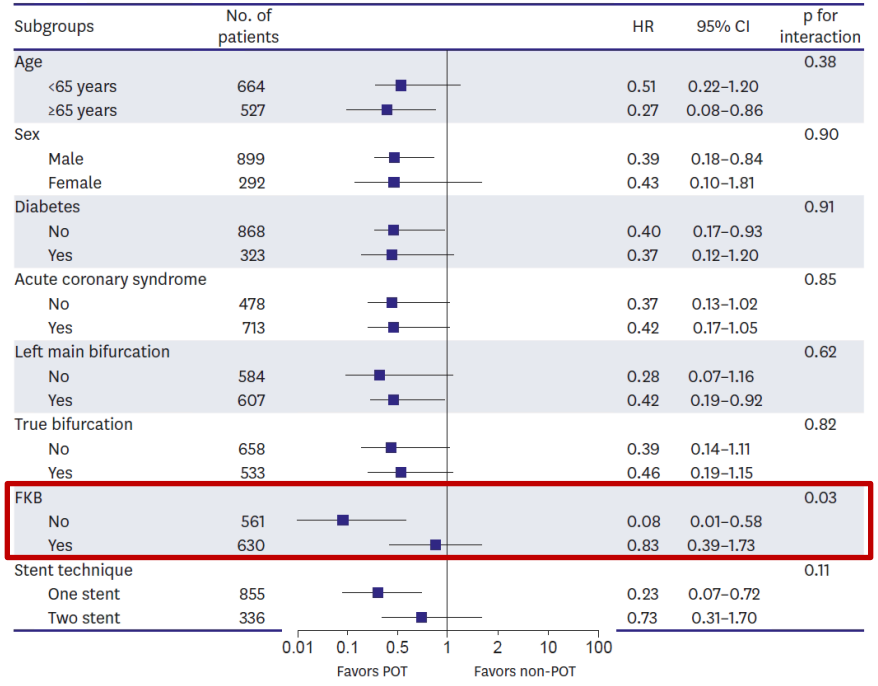

J. Van Rothem, EBC 2012

# Proximal Optimization Technique vs Final Kissing Balloon

Target lesion failure in propensity score-matched population in COBIS II registry




| No. at risk | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| POT | 240 | 213 | 180 | 113 | 47 | 20 | 4 | 1 | |
| non-POT | 853 | 730 | 609 | 370 | 199 | 102 | 41 | 14 | 2 |



| Subgroups | No. of patients | HR | 95% CI | p for interaction |
|---|---|---|---|---|
| Age | | | | 0.38 |
| <65 years | 664 | 0.51 | 0.22–1.20 | |
| ≥65 years | 527 | 0.27 | 0.08–0.86 | |
| Sex | | | | 0.90 |
| Male | 899 | 0.39 | 0.18–0.84 | |
| Female | 292 | 0.43 | 0.10–1.81 | |
| Diabetes | | | | 0.91 |
| No | 868 | 0.40 | 0.17–0.93 | |
| Yes | 323 | 0.37 | 0.12–1.20 | |
| Acute coronary syndrome | | | | 0.85 |
| No | 478 | 0.37 | 0.13–1.02 | |
| Yes | 713 | 0.42 | 0.17–1.05 | |
| Left main bifurcation | | | | 0.62 |
| No | 584 | 0.28 | 0.07–1.16 | |
| Yes | 607 | 0.42 | 0.19–0.92 | |
| True bifurcation | | | | 0.82 |
| No | 658 | 0.39 | 0.14–1.11 | |
| Yes | 533 | 0.46 | 0.19–1.15 | |
| FKB | | | | 0.03 |
| No | 561 | 0.08 | 0.01–0.58 | |
| Yes | 630 | 0.83 | 0.39–1.73 | |
| Stent technique | | | | 0.11 |
| One stent | 855 | 0.23 | 0.07–0.72 | |
| Two stent | 336 | 0.73 | 0.31–1.70 | |

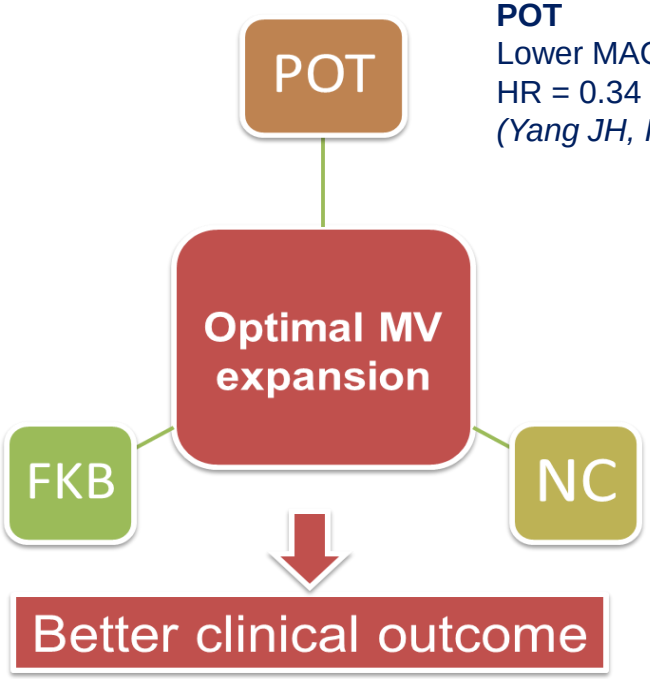


*POT = proximal optimization technique*
*FKB = final kissing ballooning*

Yang JH, Gwon HC, KCJ 2019

# Optimal MV stent expansion the most important

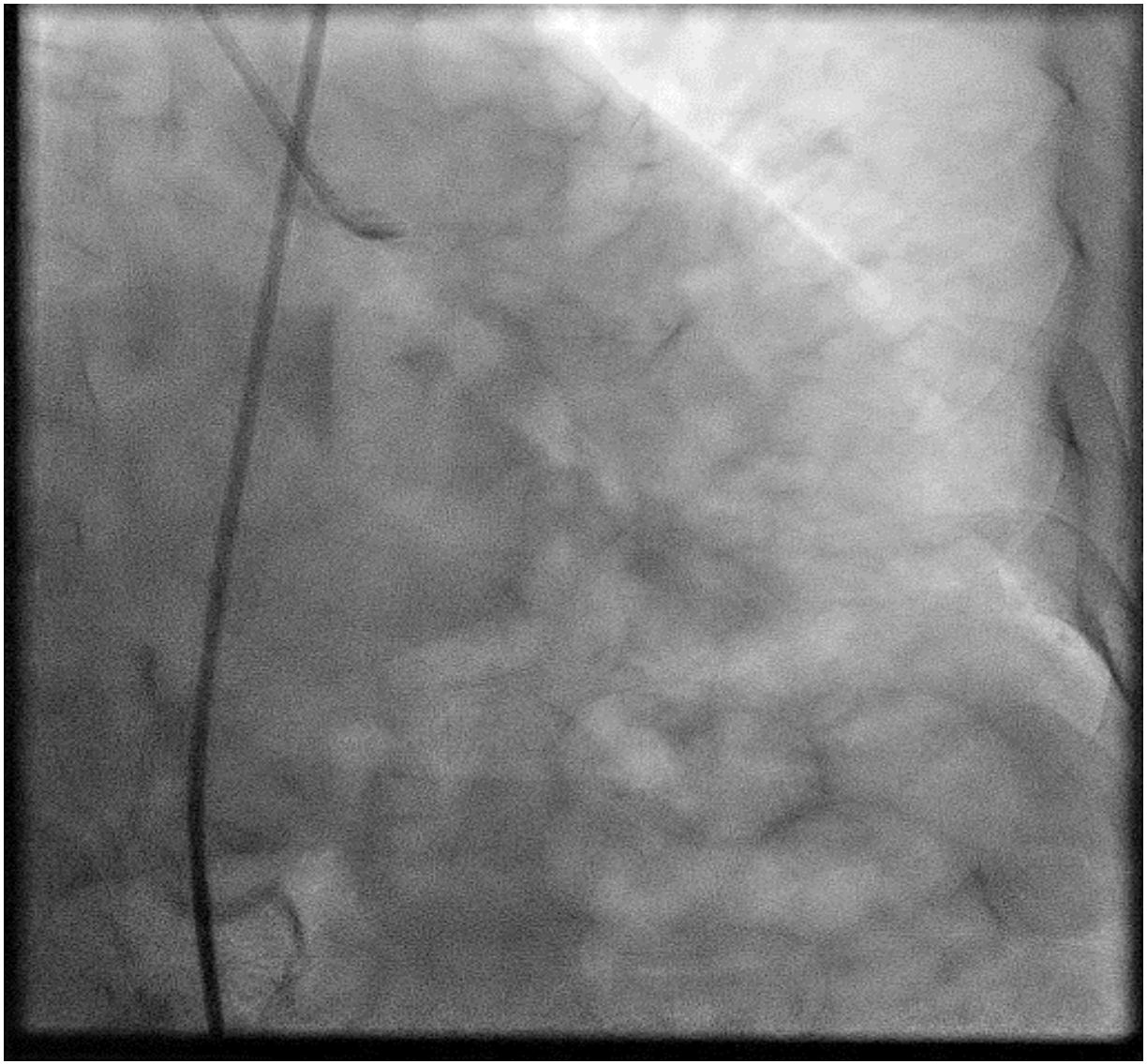
**POT**
Lower MACE
HR = 0.34 [0.17-0.69], p=0.003
*(Yang JH, KCJ 2019)*



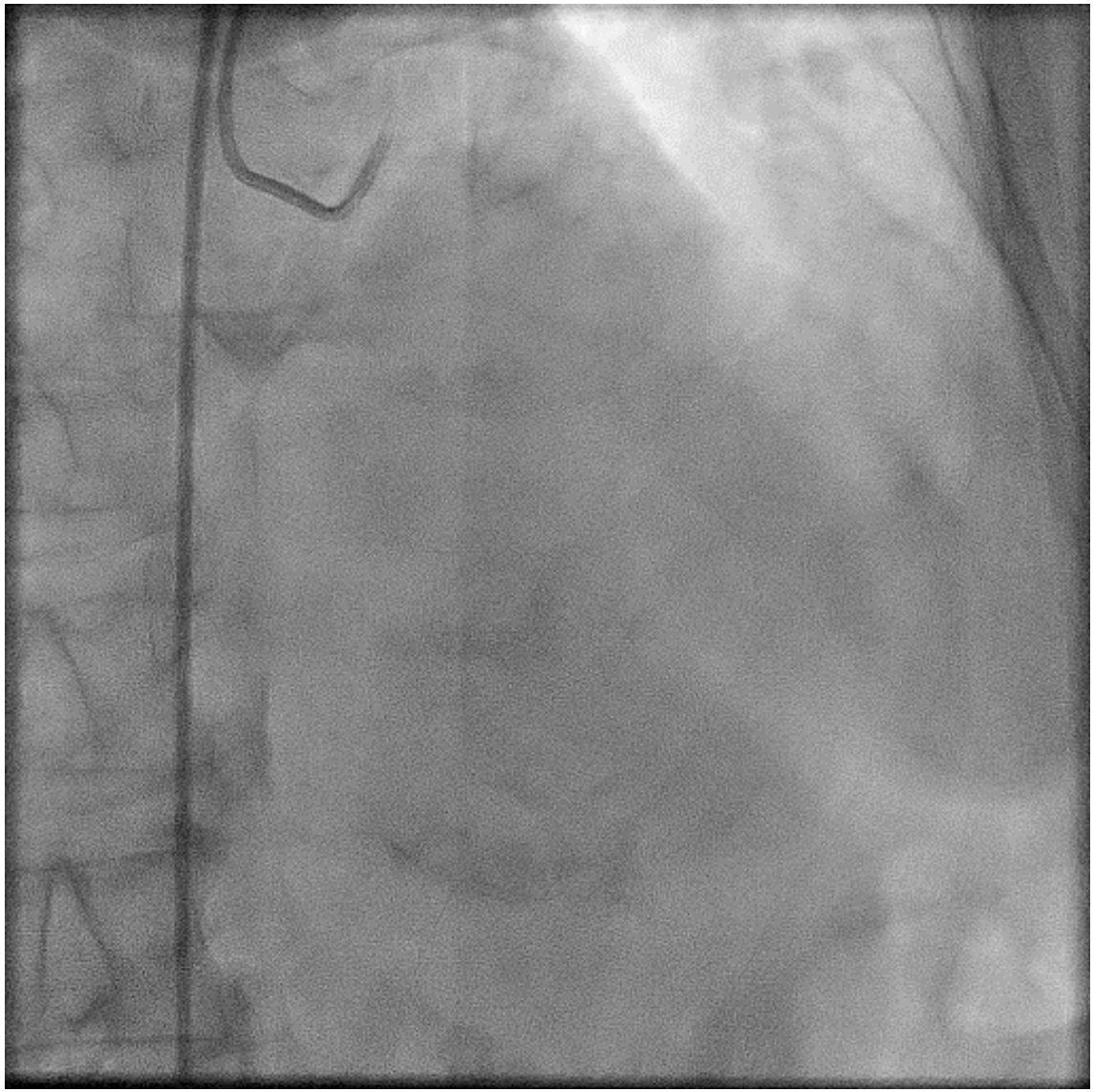

**FKB**
Lower MACE
HR=0.50 [0.30- 0.85],p = 0.01
*(Yu CW, JACC CVI 2015)*

**NC balloon**
Lower MACE
HR=0.64 [0.46-0.91], p=0.01
*(Park TK, Eurointervention 2016)*

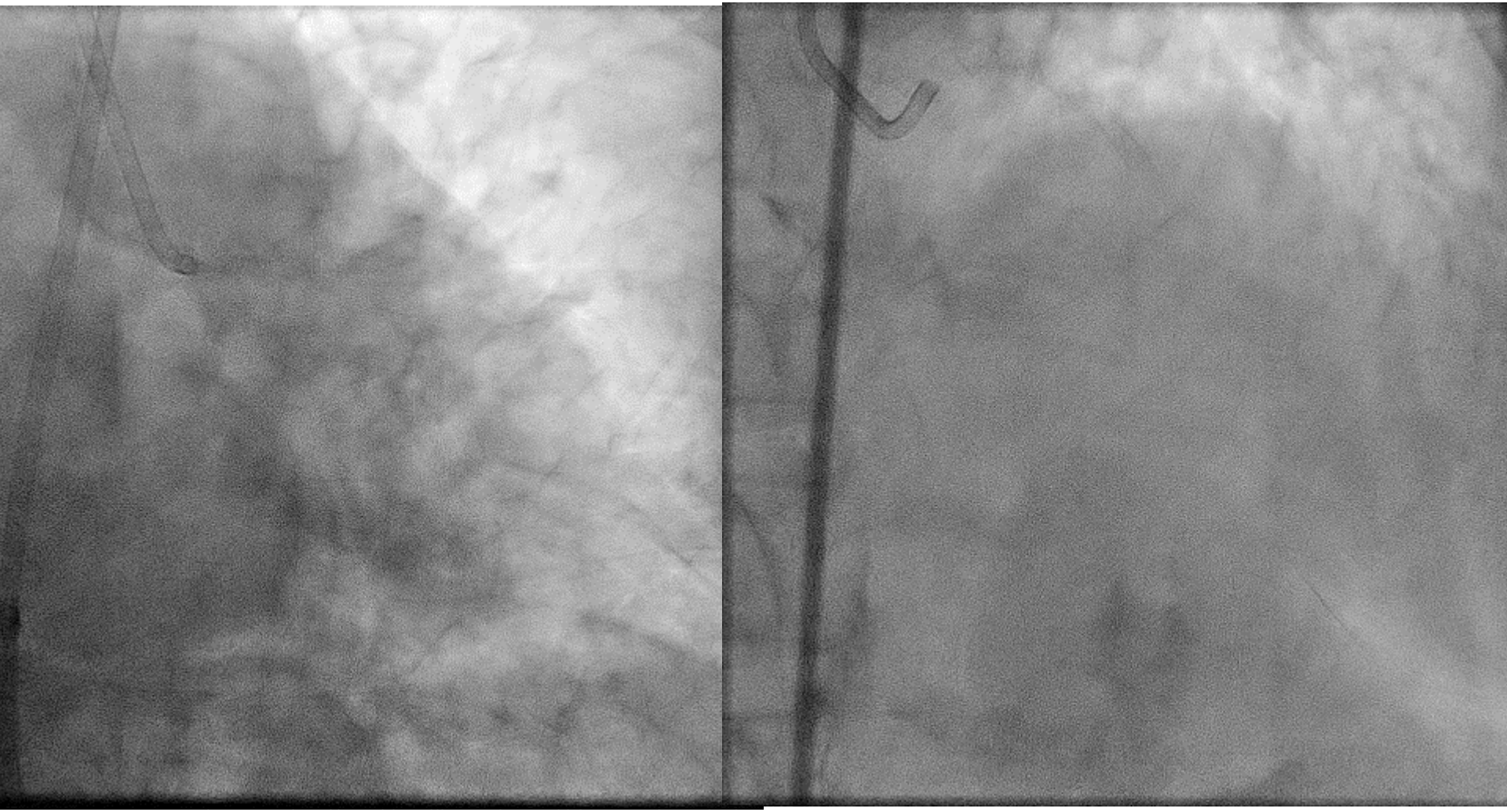
# Left Main Bifurcation



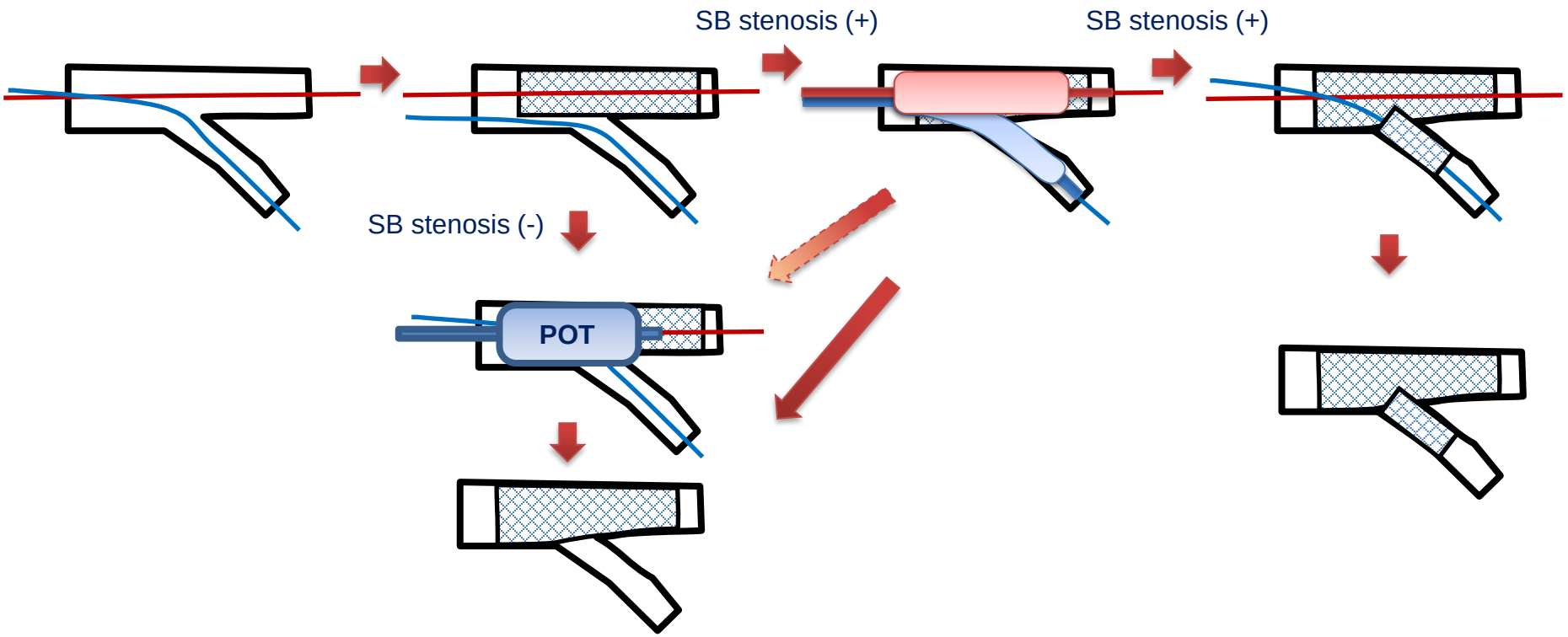
# Left Main Bifurcation



# Left Main Bifurcation-Provisional

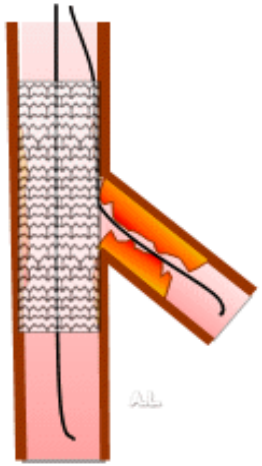
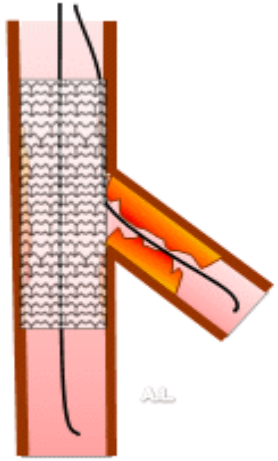
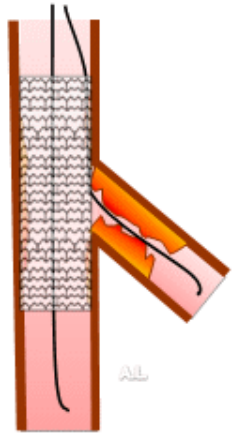


# A common approach in left main bifurcation



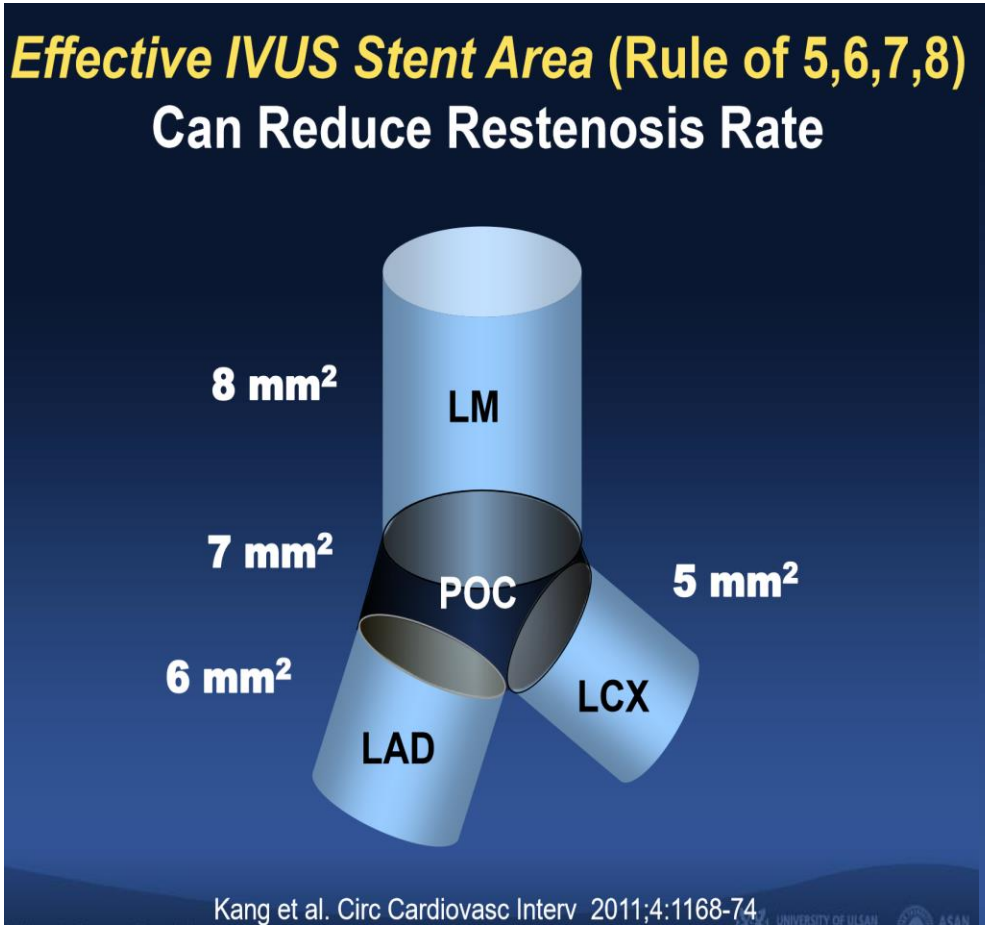
# Bifurcation Stenting- Bailout Options

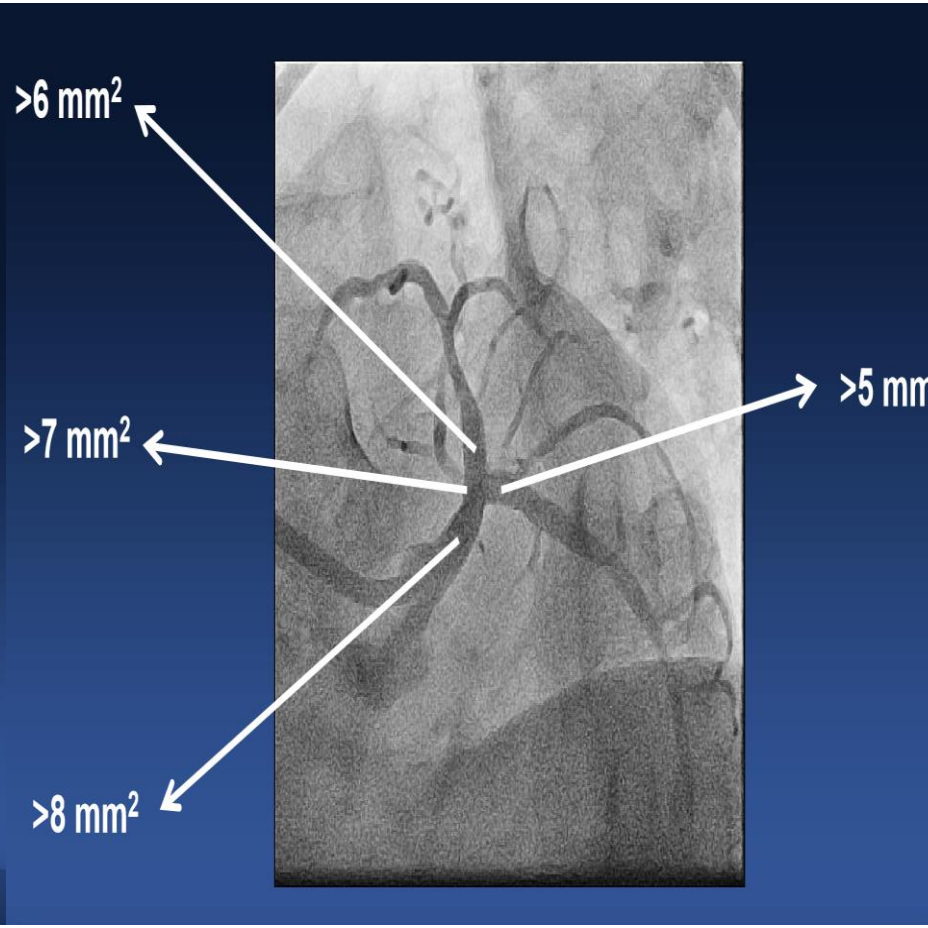
## *Provisional requiring a 2nd stent*

| | TAP | Reverse Crush | Culotte |
|---|---|---|---|
| |  |  |  |
| ***Advantages*** | Easy to perform<br>No recrossing | Complete coverage of ostium<br>Any anatomy | Complete coverage of ostium |
| ***Disadvantages*** | Struts protruding into MB | Recrossing into SB<br>3 layers of struts | More difficult rewiring Of both branches<br>Double stent layer |

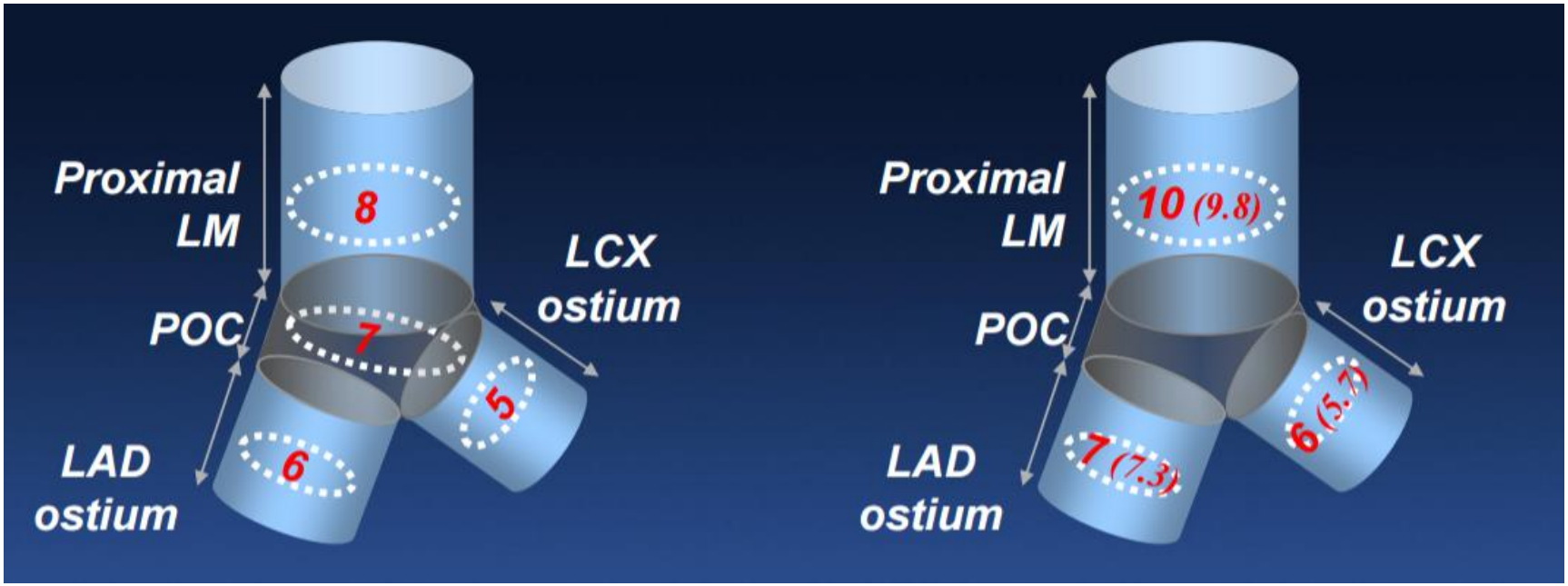
# Two Stent Bifurcation Techniques

# LEFT MAIN


Effective IVUS Stent Area (Rule of 5,6,7,8)
Can Reduce Restenosis Rate
8 mm²
LM
7 mm²
POC
5 mm²
6 mm²
LCX
LAD
Kang et al. Circ Cardiovasc Interv 2011;4:1168-74


>6 mm²
>7 mm²
>8 mm²
>5 mm

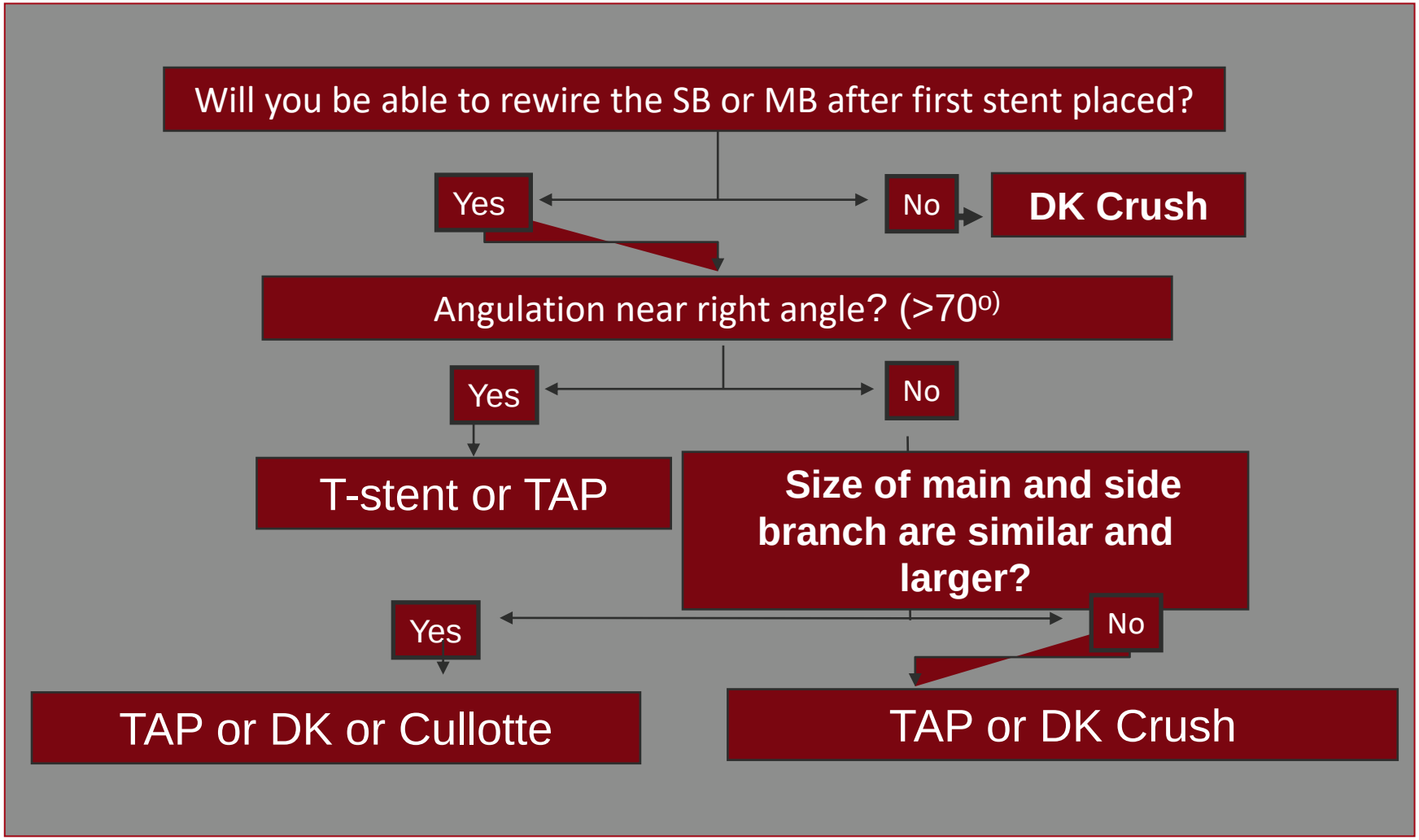
# Minimum achievement criteria of MSA




Kang SJ, et al. Circ Cardiovasc Interv 2011;4:562-9

EXCEL trial analysis
A. Maehara TCT 2018

# Deciding Which Two-Stent Approach



# Two Stent Strategies

*When to perform? Which technique?*

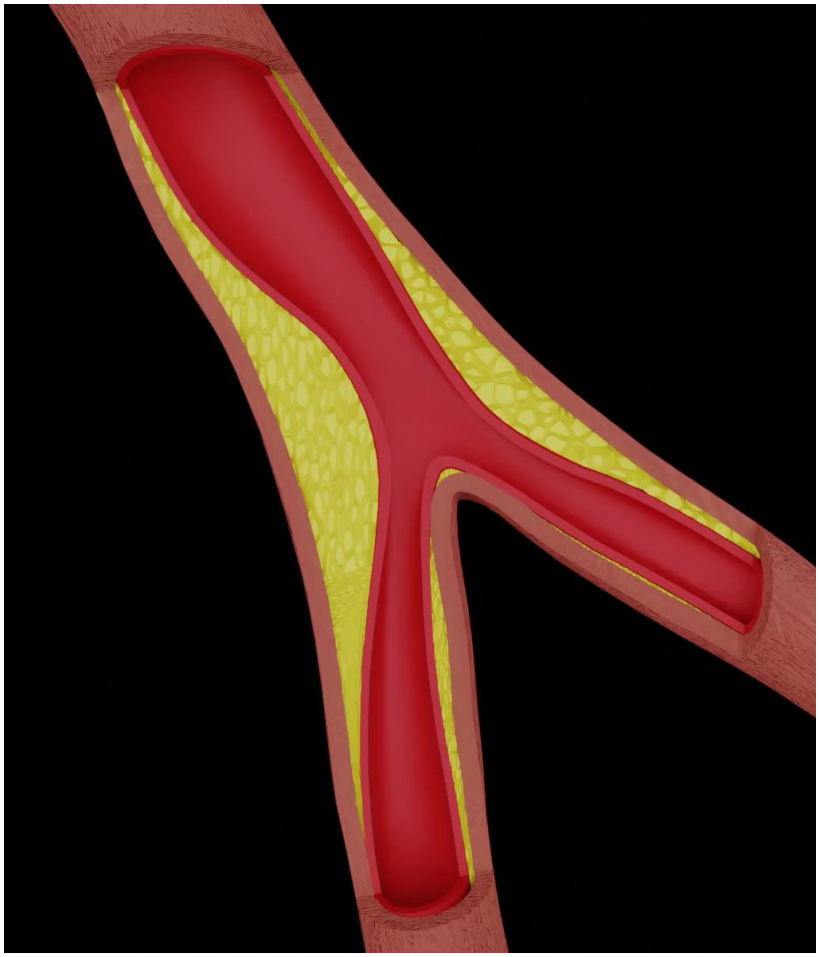
| Technique | SIZE daughter branches | Angle | Provisional | Complexity |
|---|---|---|---|---|
| Culotte | SB ≈ MV | wide range (<55° preferred) | suitable | 2 rewiring 5 steps (+1-3 POT) |
| T-Stenting (TAP) | SB << MV | ≈ 90° | suitable | 1 rewiring 3 steps (1-2 POT) |
| DKCrush (mini-crush) | SB < MV | < 90° | no | 2 rewiring 6 steps (1-2 POT) |
| SKS | SB ≈ MV | wide range | no | no rewiring 1 step (no POT) |

N Foin ..C Di Mario et al Circ J 2013; 77:73–80

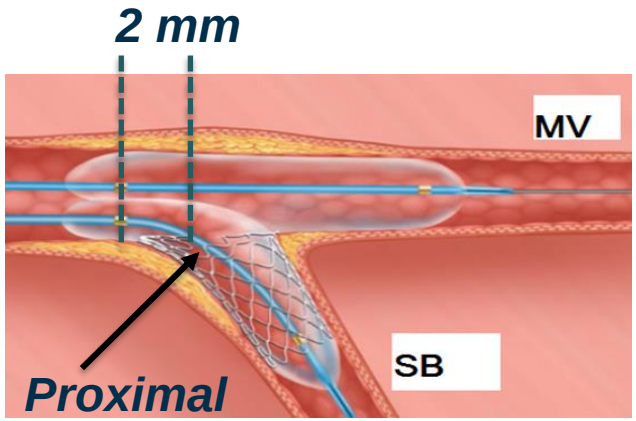
# DK-Crush Technique

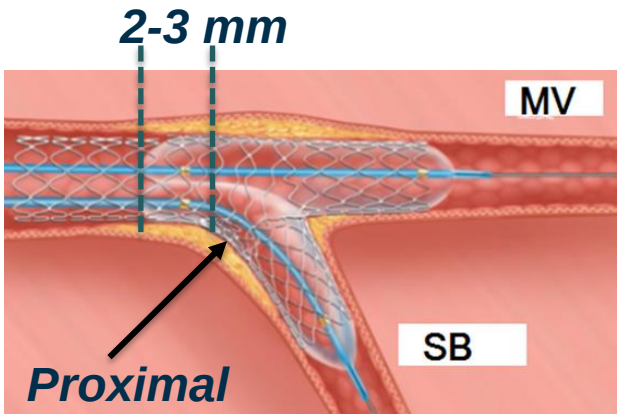
Courtesy Dr. Goran Stankovic
ESC Bifurcation Club and Arch

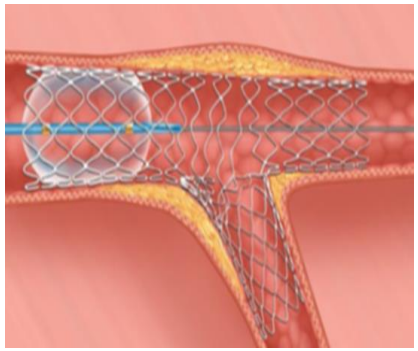
# DK-Crush Stenting: Step-by-Step



# Take-home message: Key points of DK crush stenting



1. Short protrusion-SB stent
2. Balloon crush
3. Rewire from proximal cell
4. Alternative inflation-16atm
5. 1st kissing

1. Stenting MV
2. Rewire from proximal cell
3. Alternative inflation
4. 2nd kissing

POT

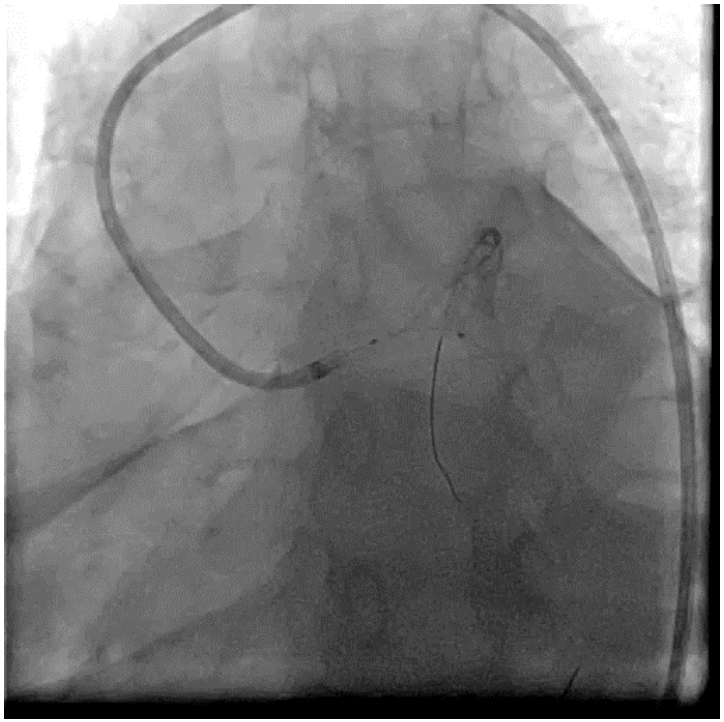
Short overlapping of 2 balloons

# Introduction of 2 cases

**Case 1:** 55-yr, Male, UAP angina

**Case 2:** 51-yr, Male, Stable

**Case 1:** after DK crush



**Case 2:** LCX was lost after stenting LAD

# Culotte Technique

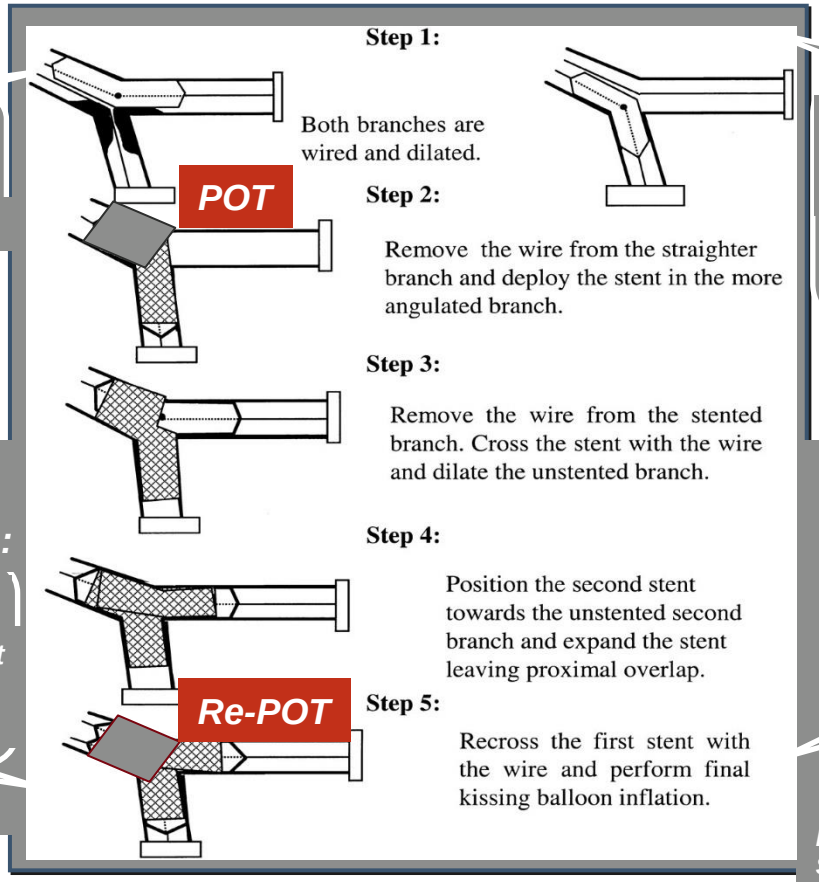
# The Culotte Stenting Technique

**Applications:**

- Left Main
- Large SB
- Restenosis in-stent

**Considerations:**

- Re-wiring for FKB
- Both advancement of 2º stent through metal struts




**Advantages:**

- Optimized stent expansion in both branches
- Suitable for lesions with wide angles

**Drawbacks:**

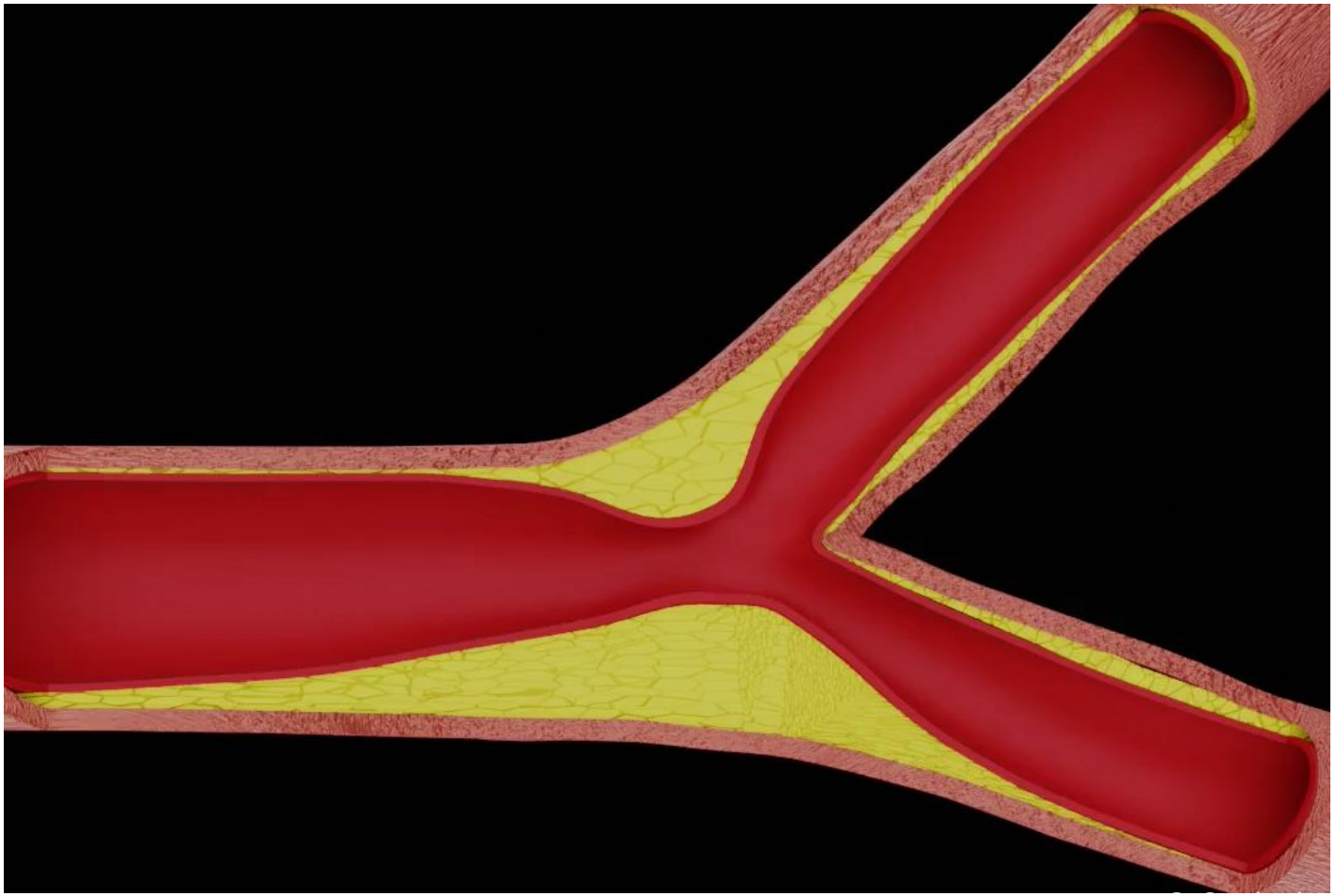
- High metal concentration at the bifurcation carina
- Inadequate stent expansion @SB

FKB: final kissing-balloon
SB: side branch

*Iakovou I. Colombo A, JACC 2006;46:1446-1455.*

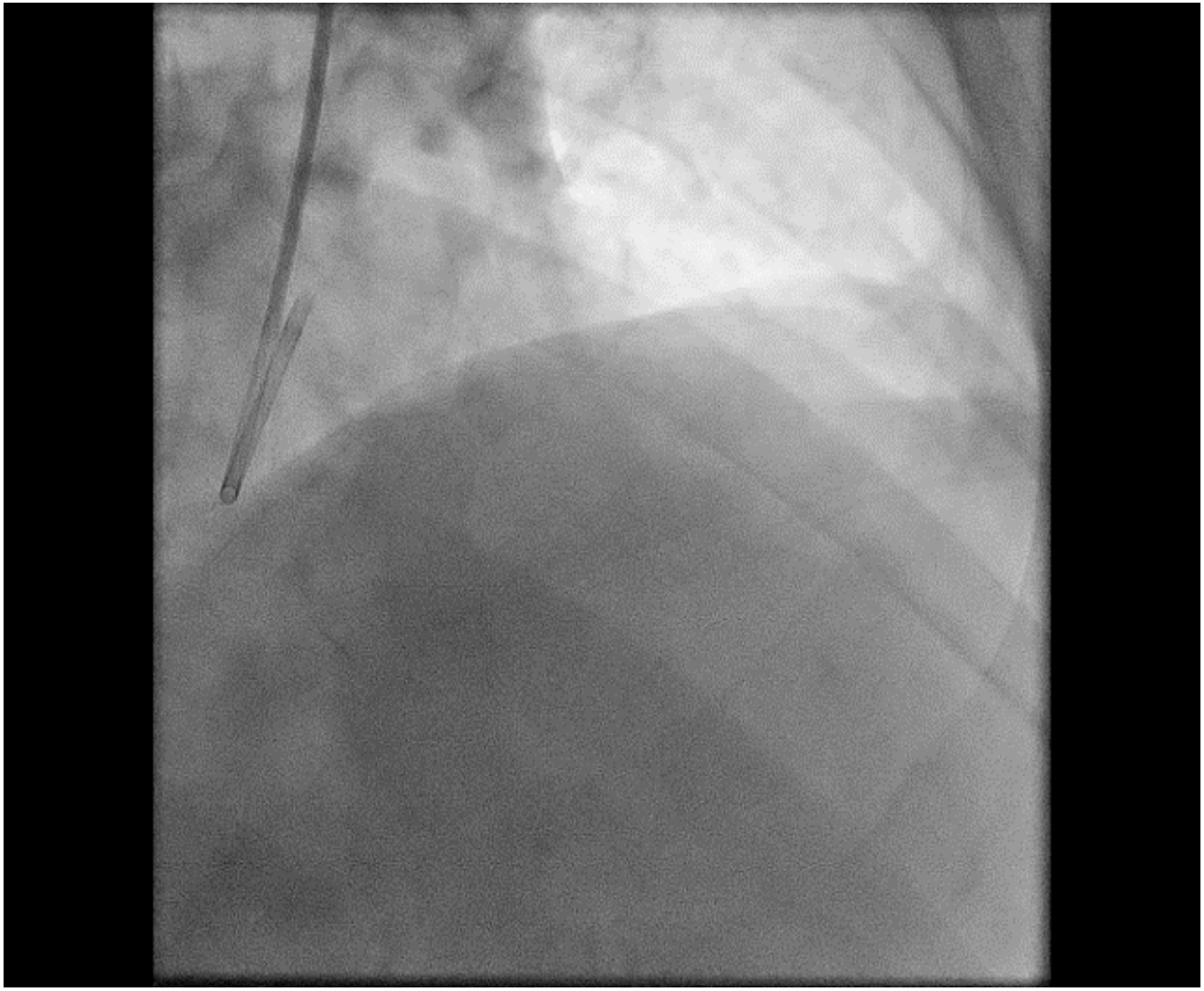
Courtesy Dr. Goran Stankovic
ESC Bifurcation Club and Arch

# Culotte Stenting: Step-by-Step

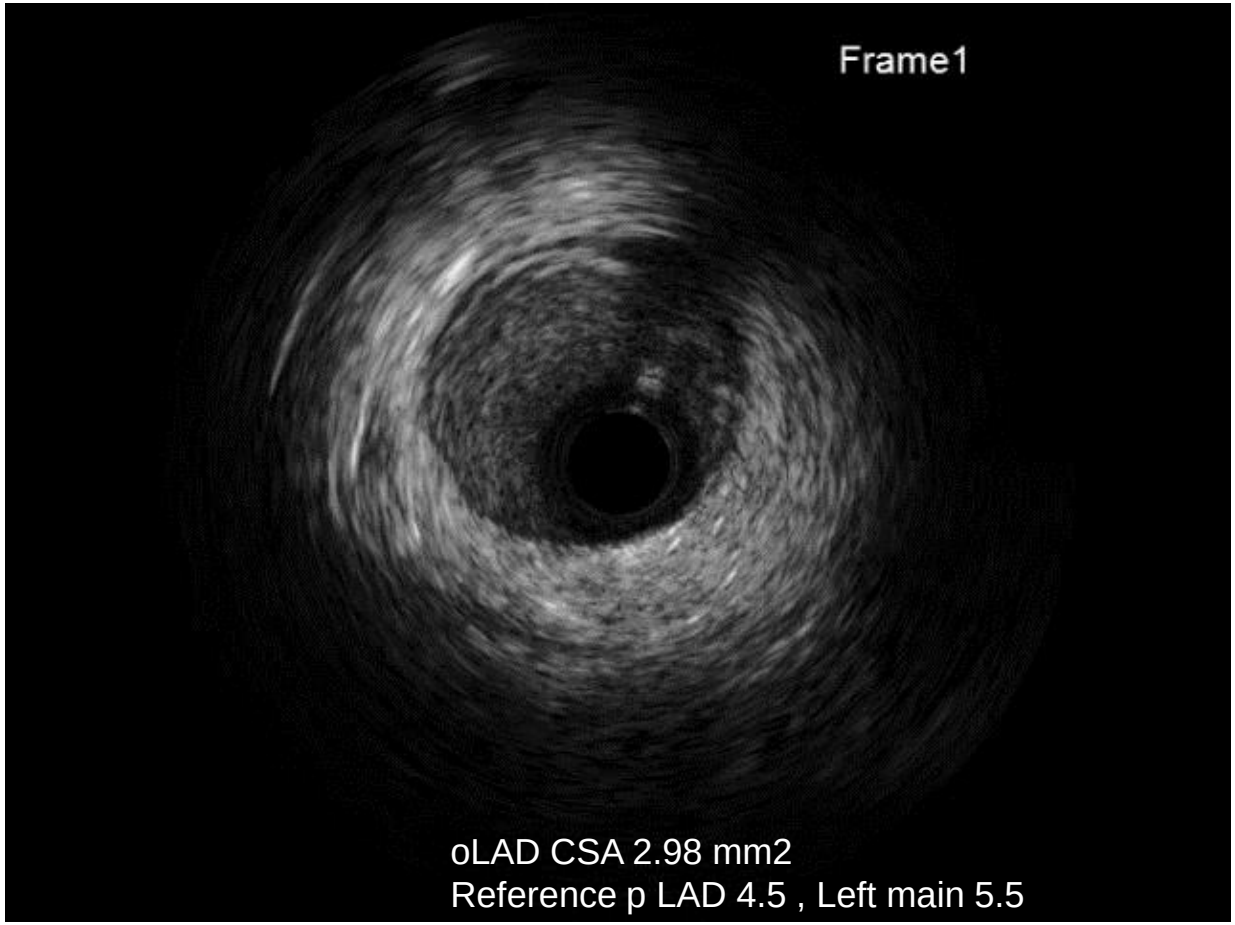


# Case-Dual bifurcations

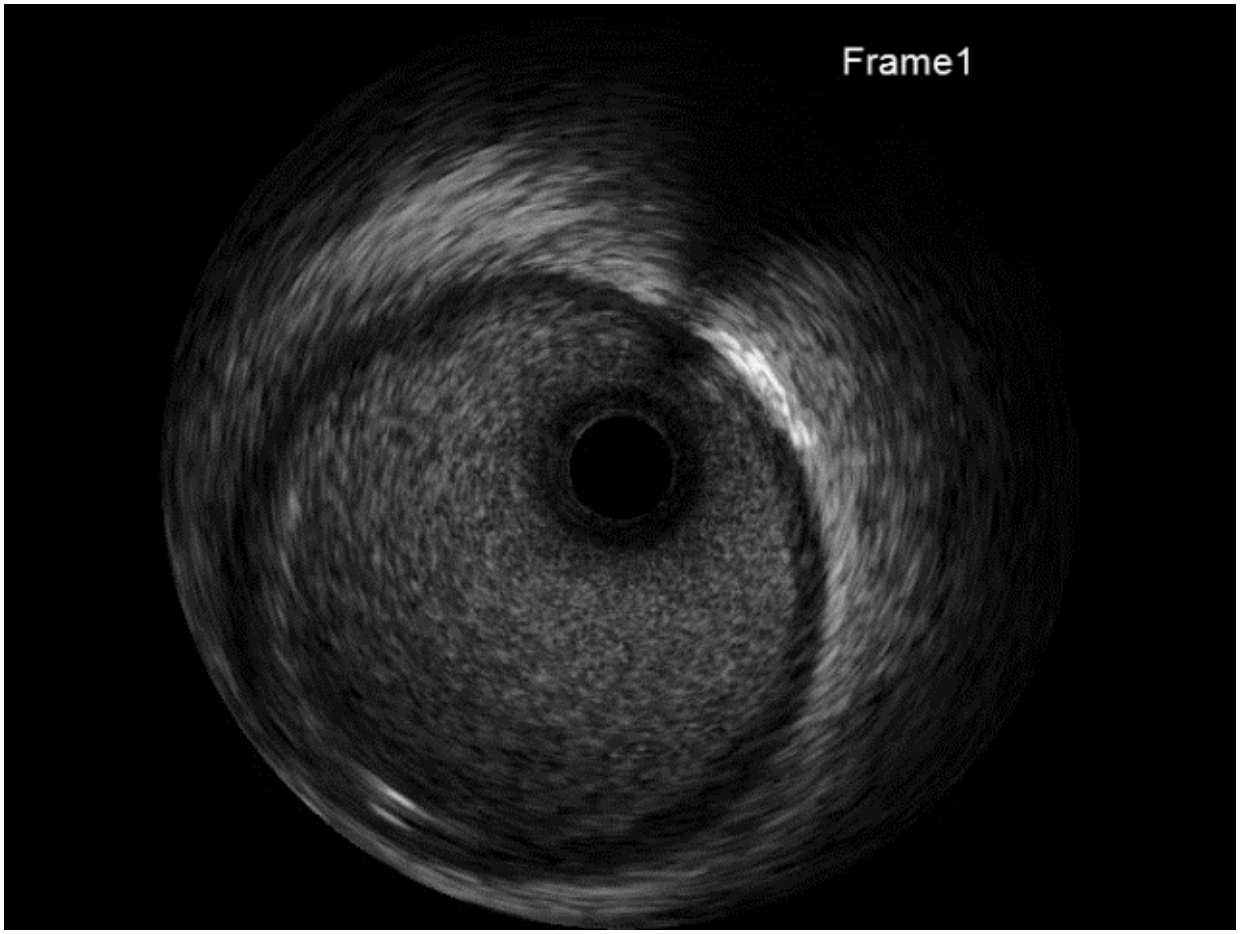
# Medina 1,1,1 LM/LAD/LCX and Medina 1,1,0 LAD/D



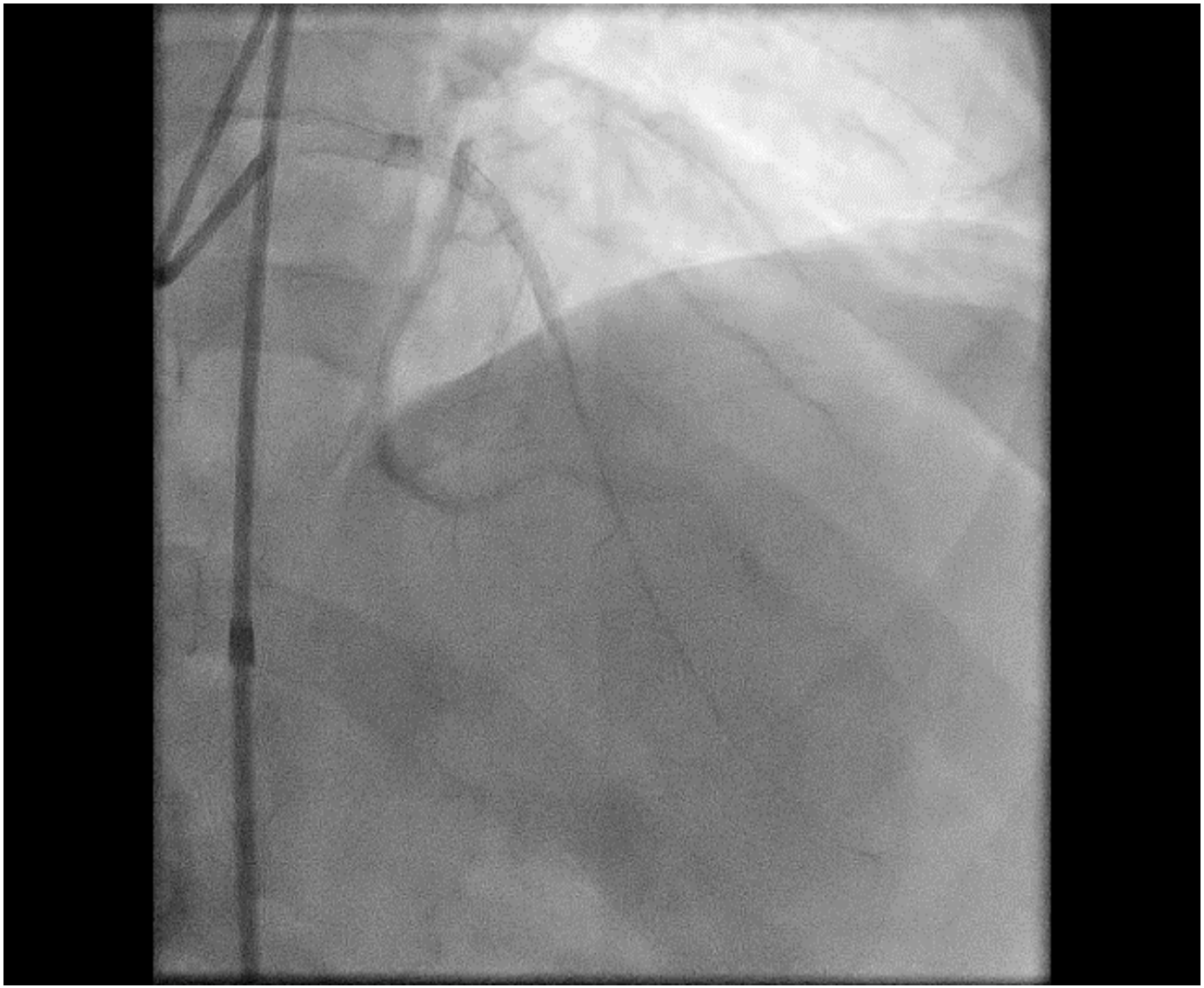
# IVUS LAD/LM



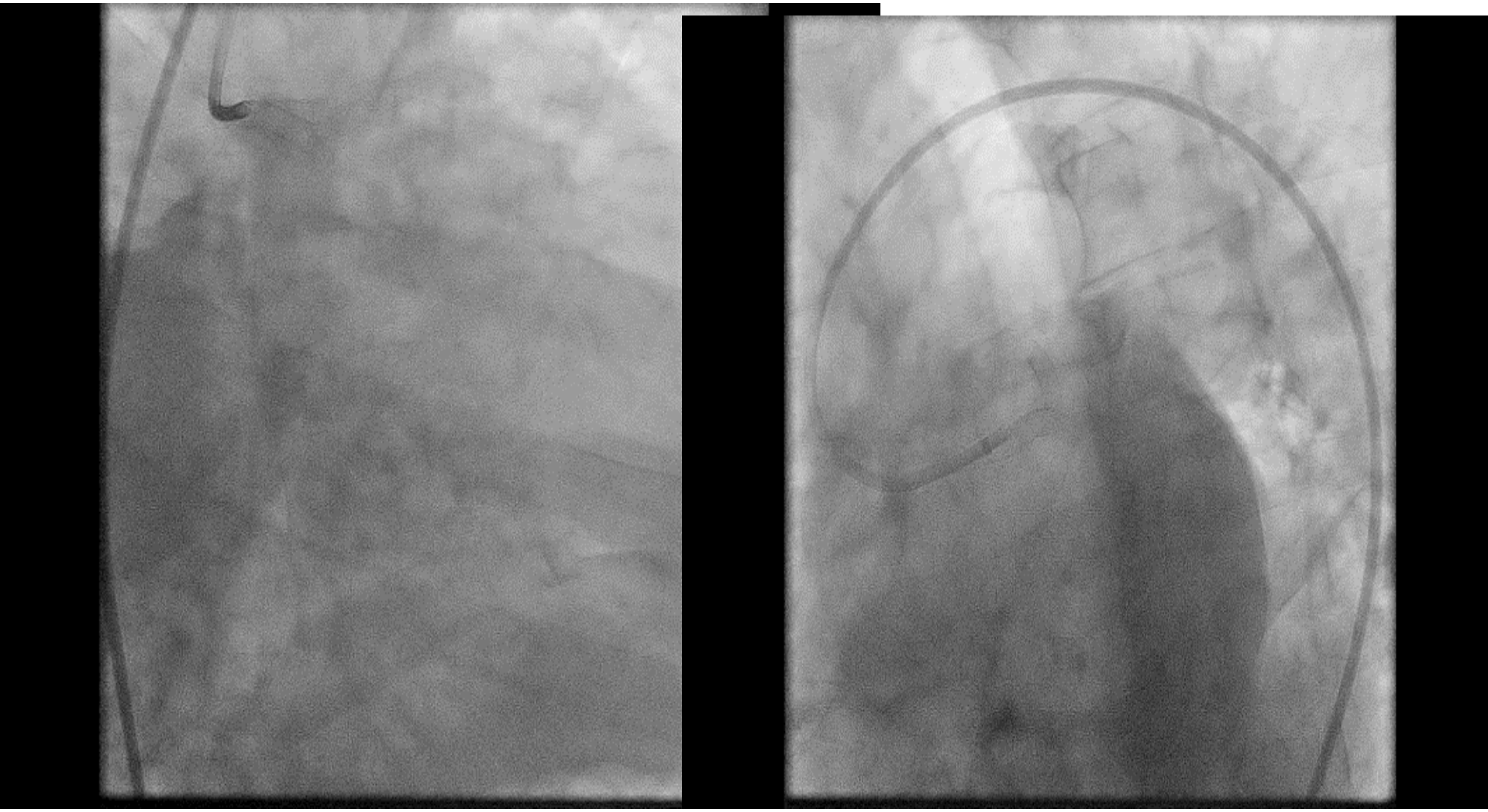
# IVUS LCx/LM



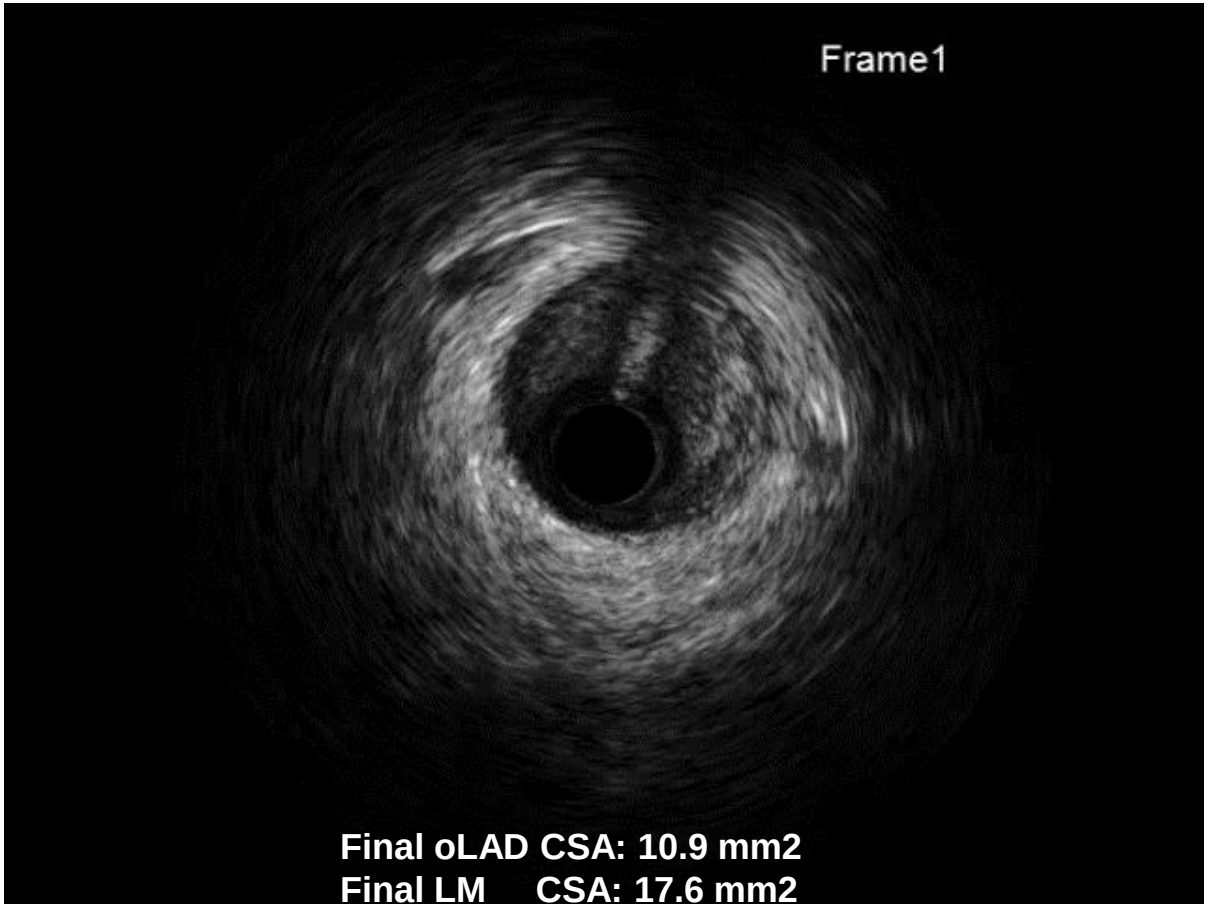
# FINAL



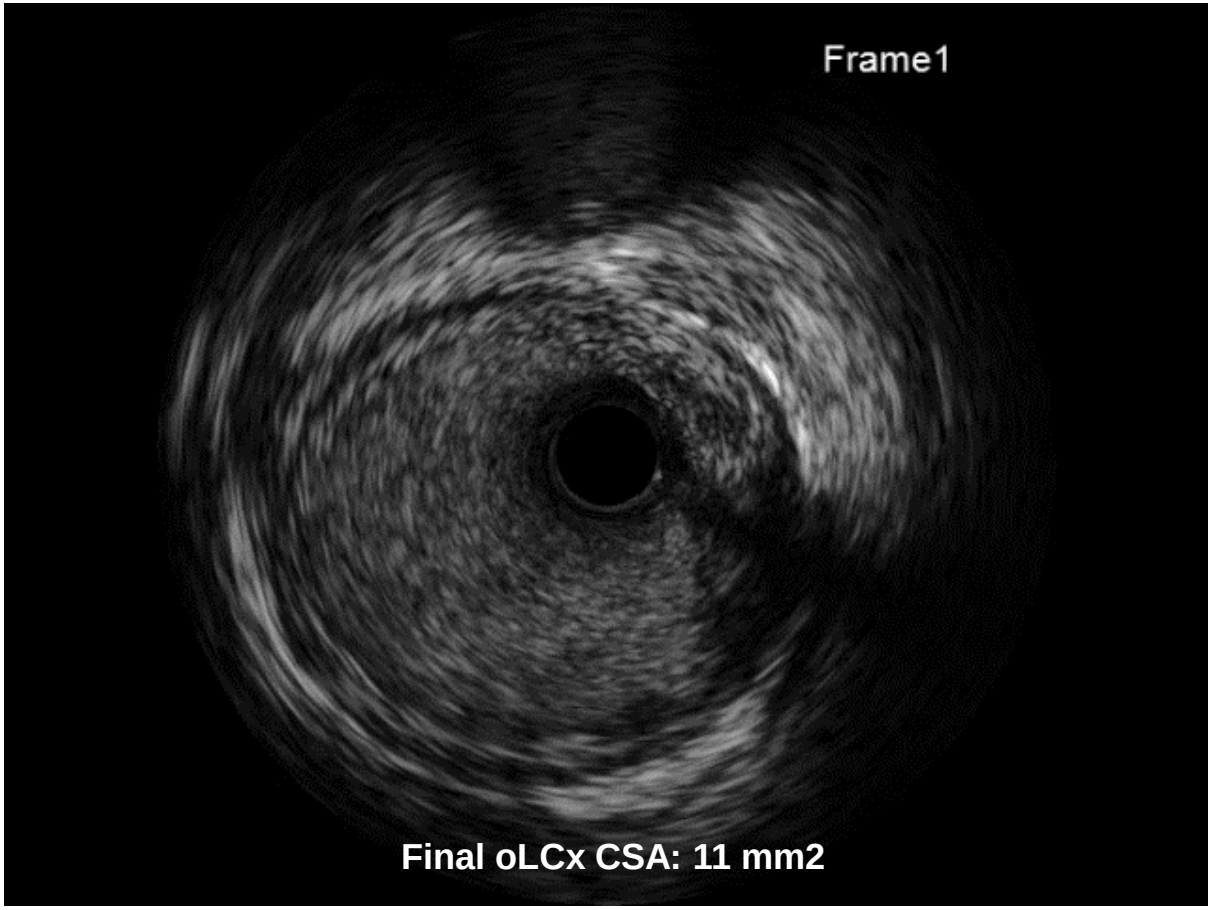
# FINAL



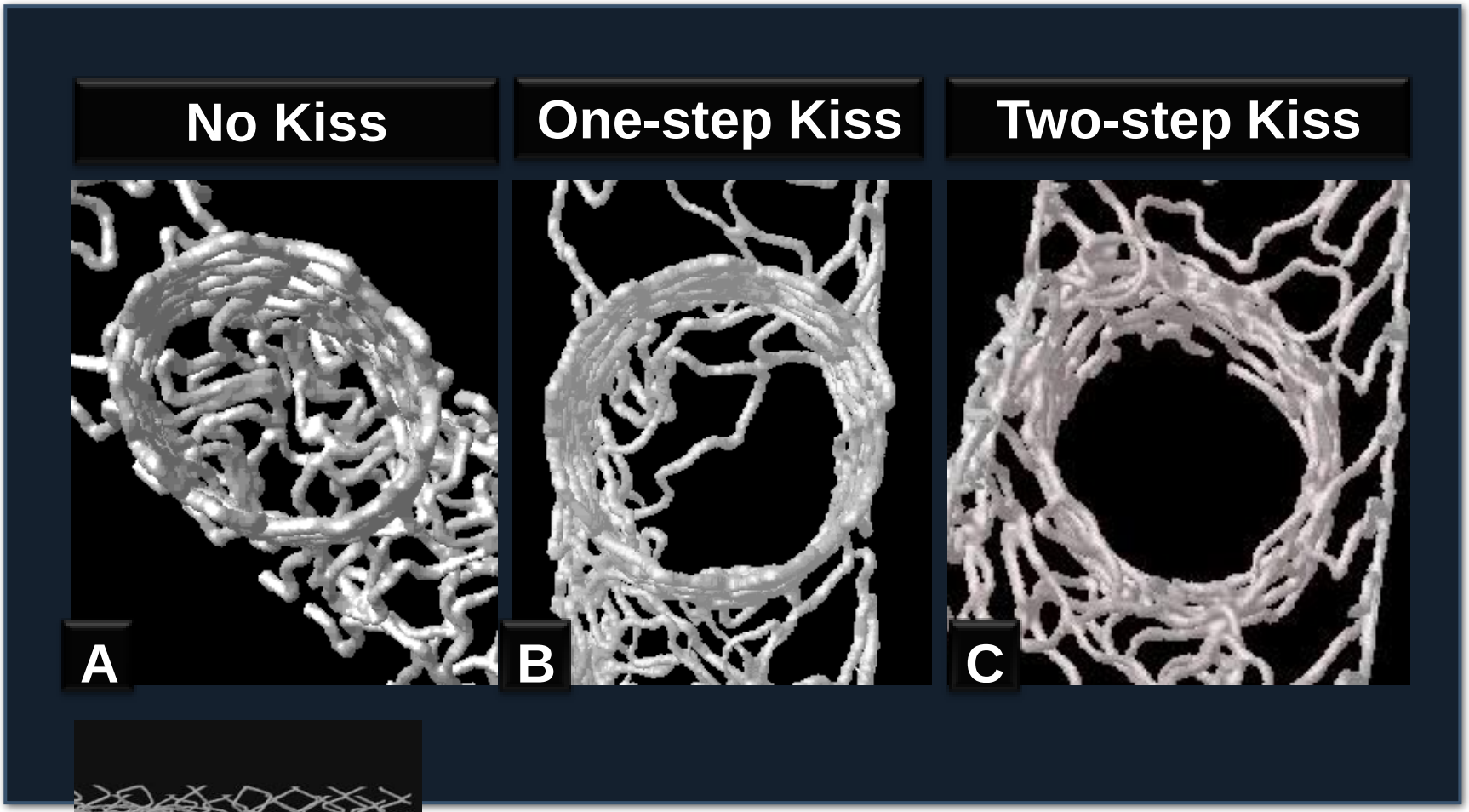
# IVUS LAD/LM Final

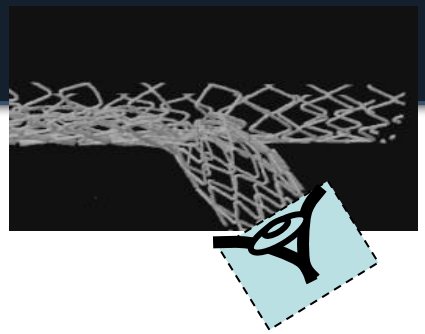


# IVUS LCx/LM Final



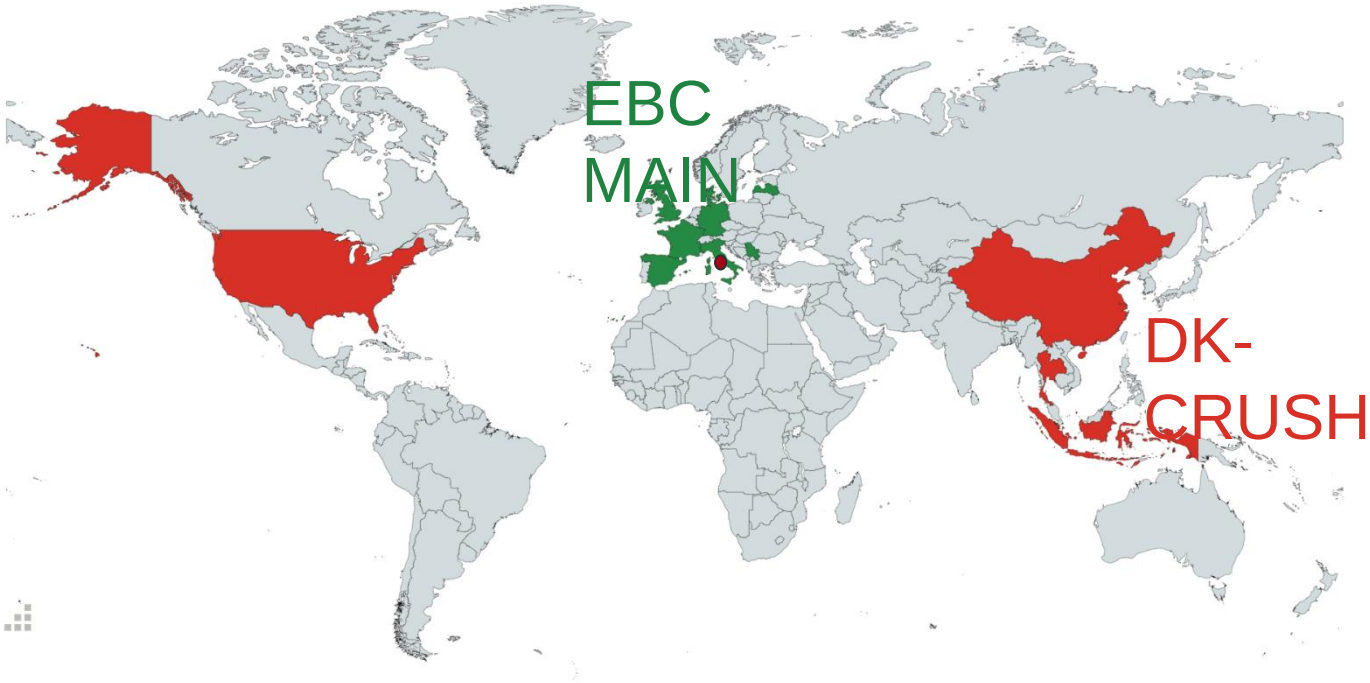
# 2-Step Kiss



Slide courtesy of John Ormiston

# One stent or two stents: that is STILL the question



# Left Main Bifurcation Stenting - Summary

- The goal of PCI in bifurcation lesions is to attain optimal results in the MV and maintain physiologic patency of the SB. Planning of the strategy up front is critical and knowledge of all possible bailout techniques must be kept in mind.
- While provisional SB stenting should be the default technique for “low-risk” bifurcations a 2-stent technique may be preferable for “high-risk” or true bifurcations

# Bifurcation Stenting - Summary

- Although evidence is lacking as to the superiority of one 2-stent technique versus others its unlikely that any single 2-stent technique would be superior in all bifurcation morphologies. The DK crush technique seems to be most favorable but TAP and Culotte techniques are also excellent options.

- The decision as to which 2-stent technique to use should be driven by bifurcation morphology, operator experience and randomized controlled trials.