Samsung Medical Center
Cardiac & Vascular Center

# The Role of IVUS in Coronary Bifurcation Stenting

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# Bifurcation Stenting

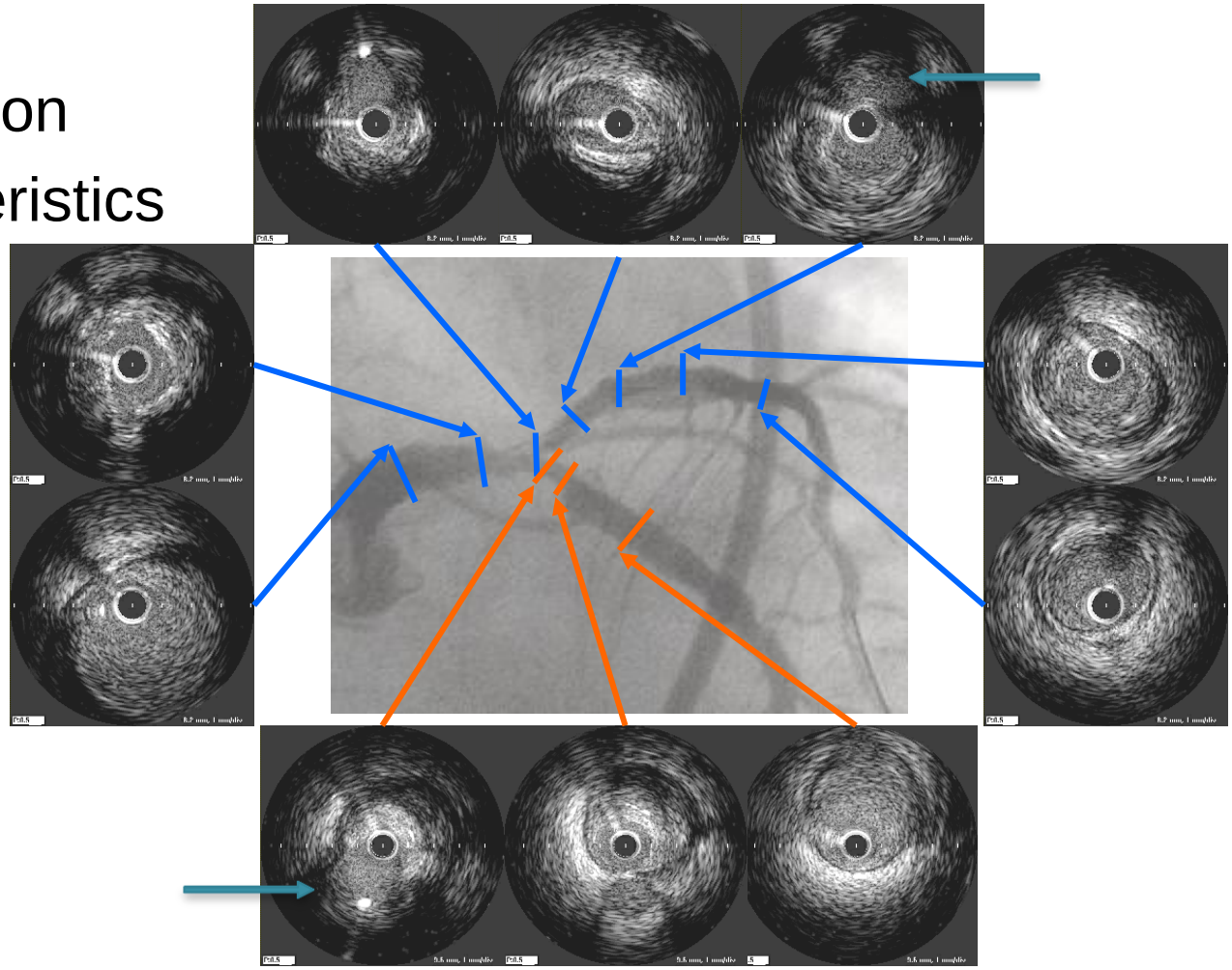
- Associated with a high risk of complications

  Side branch occlusion, incomplete stent expansion, myonecrosis, restenosis, stent thrombosis

- Guidance for the procedure
  - IVUS guidance
  - OCT guidance
  - FFR guidance

# IVUS-Guided PCI
# Pre-PCI IVUS Examination

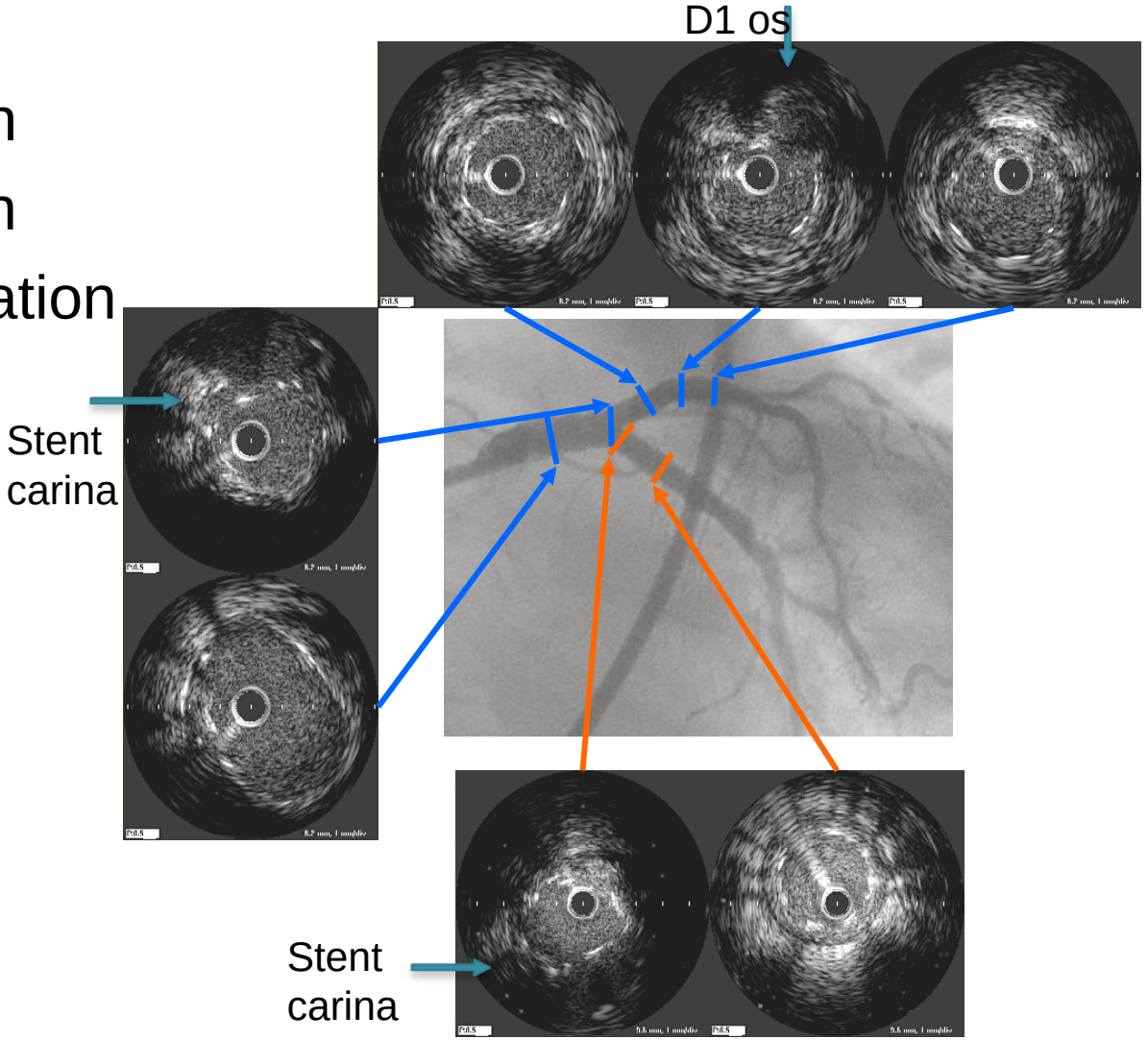
- Vessel size
- Plaque distribution
- Plaque characteristics
- SB os disease



SB = side branch

# IVUS-Guided PCI
# Post-PCI Examination

- Stent apposition
- Stent expansion
- SB ostial evaluation
- Dissection

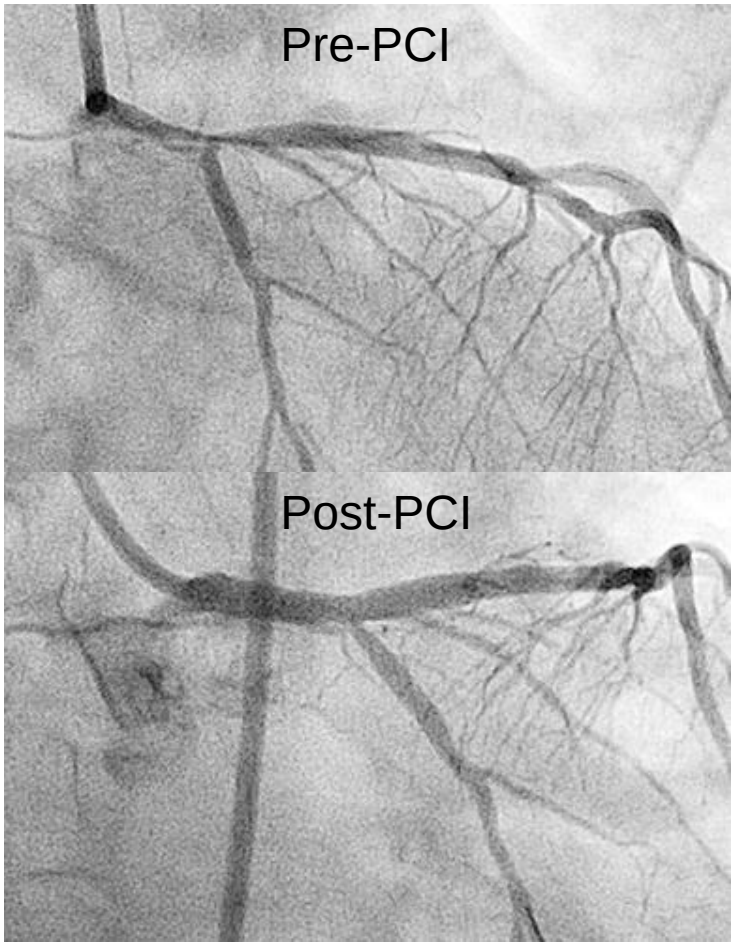


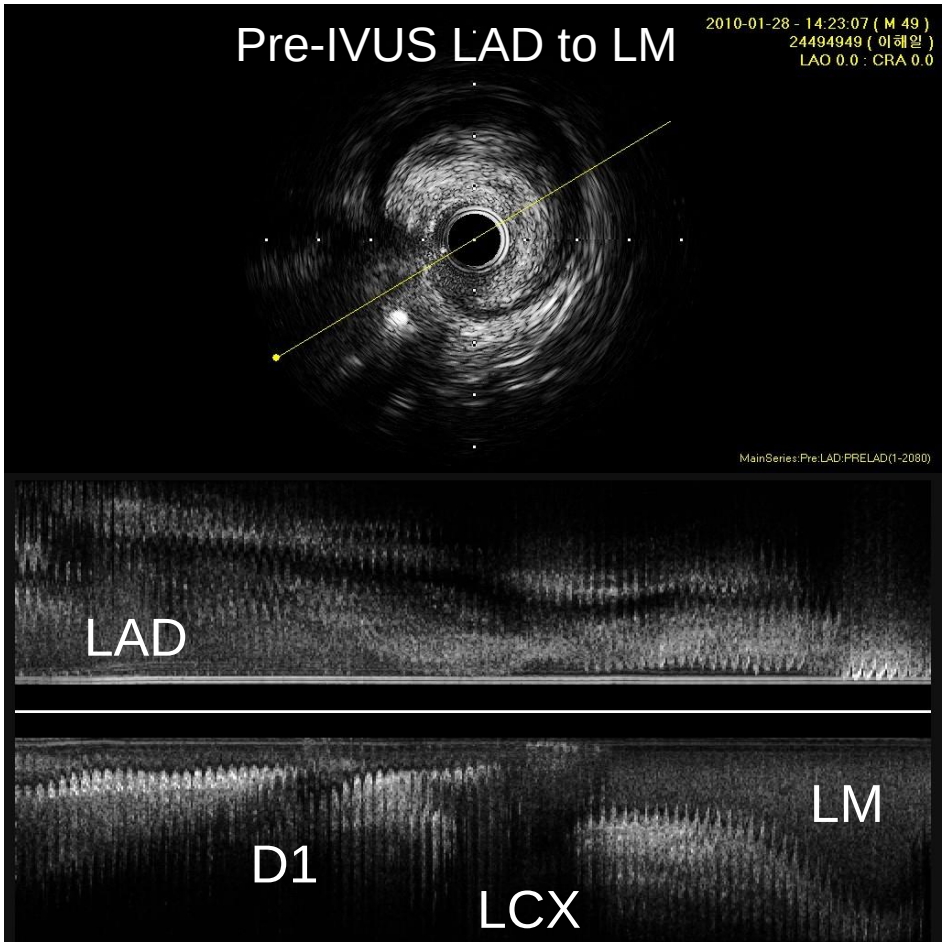

SB = side branch

# Vessel size

## the most important information for bifurcation stenting

Angiography is misleading



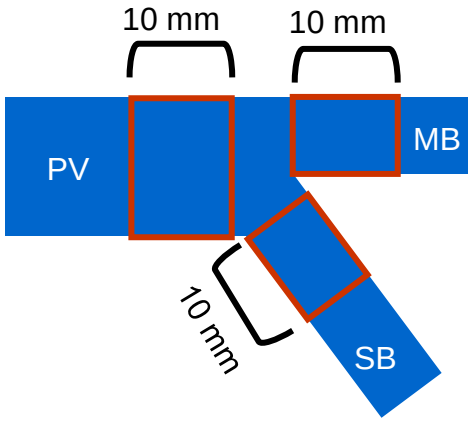



# Vessel Size Information is Critical

Kissing ballooning is most likely oversized in the parent vessel

| | PV | MB + SB | p-value |
|---|---|---|---|
| $D^2$ | 16.0±4.3 | 19.2±5.1 | <0.001 |
| $D^3$ | 95.5±38.9 | 90.7±36.1 | 0.35 |

D = Vessel diameter

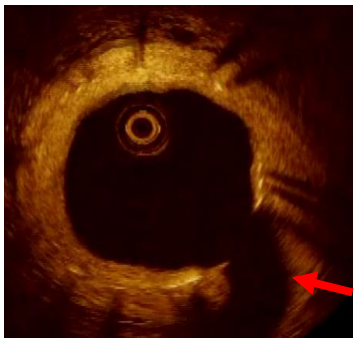


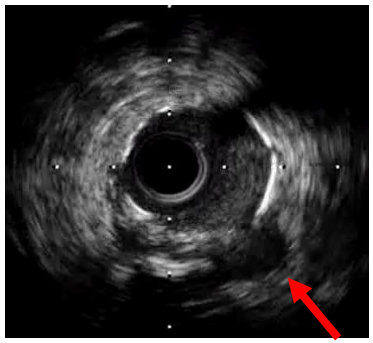

**Vessel area ($D^2$)** : PV < MB + SB

**$D^3$** : PV = MB + SB (Murray's Law)

# OCT vs. IVUS

- Advantage of OCT
  - Far better resolution
- Disadvantage of OCT
  - Shallow penetration
    - No information on vessel size and plaque distribution

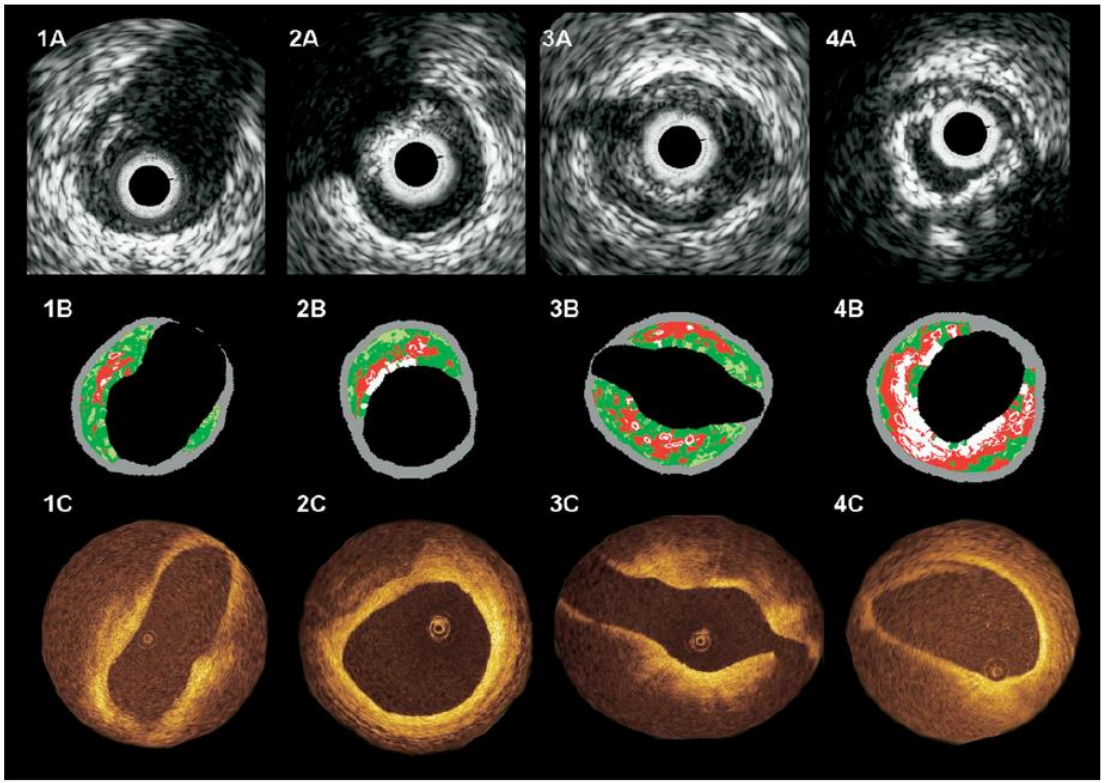




**OCT may not suitable for the procedure guidance.**

# Plaque Characteristics

- Gray-scale vs. virtual histology




* The location and the extent of calcium is important for the procedure.

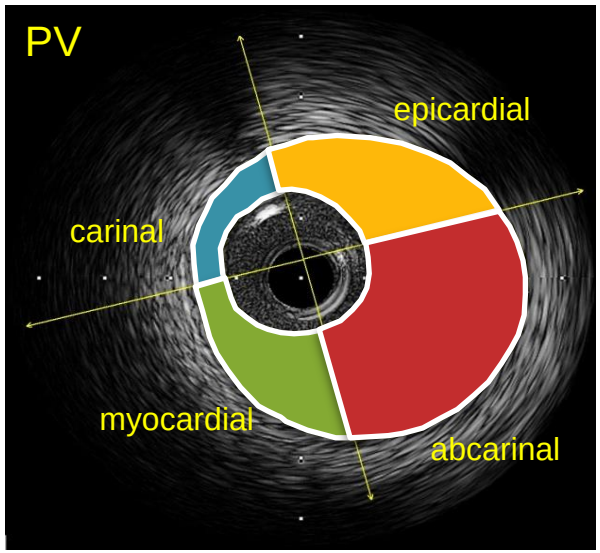
* A higher proportion of dense calcium and a lower proportion of fibrous and fibrofatty tissue in the contralateral vessel wall of bifurcation lesion.

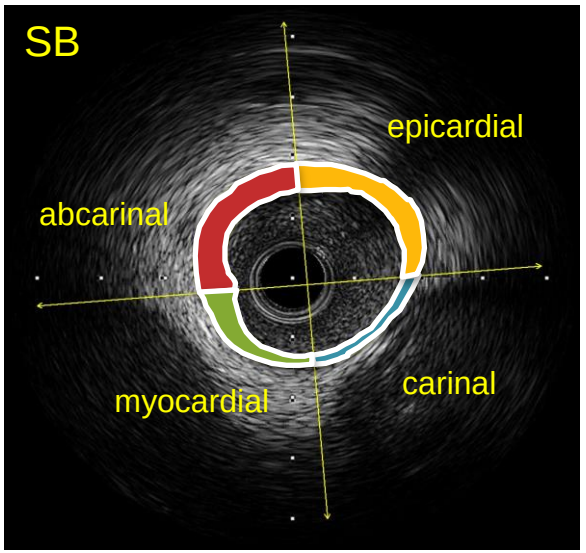
Gonzalo N, JACC Imaging 2009, Toggweilera S, Atherosclerosis 2010

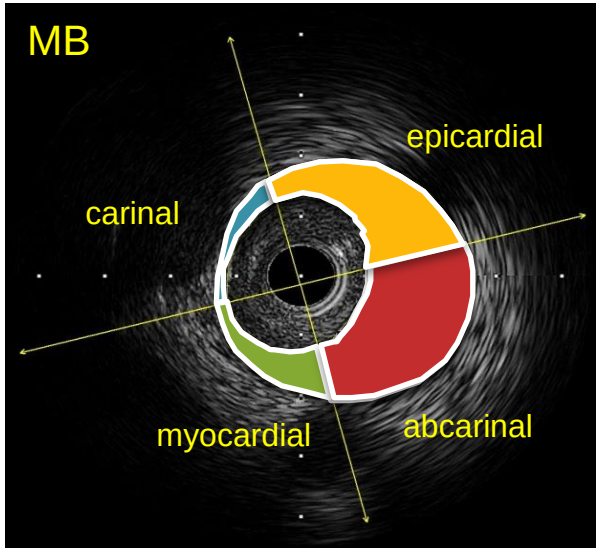
# Plaque Distribution

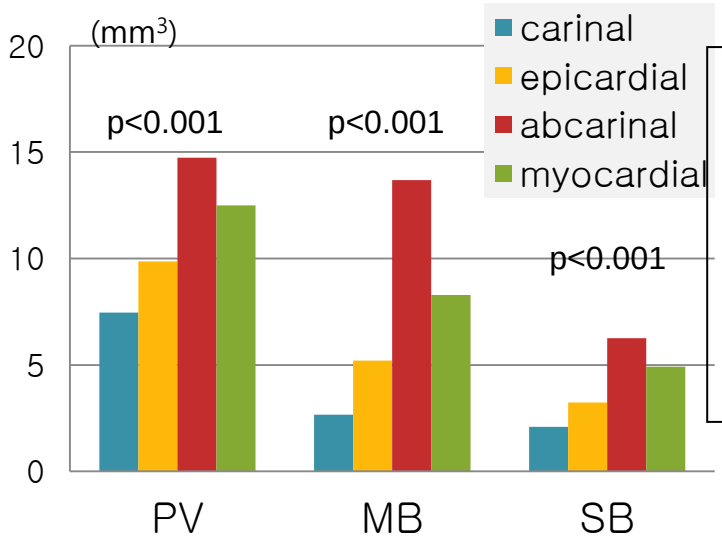
## Largest plaque burden in the opposite side of SB

N=22
IVUS
in both
MV
and SB



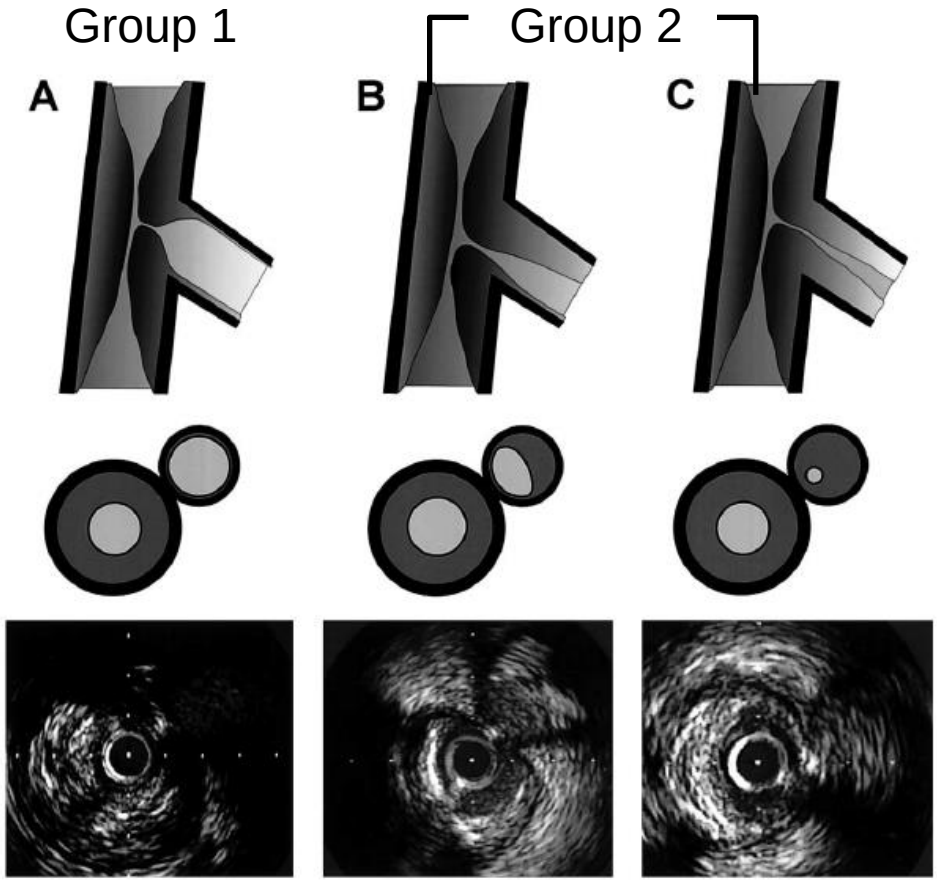



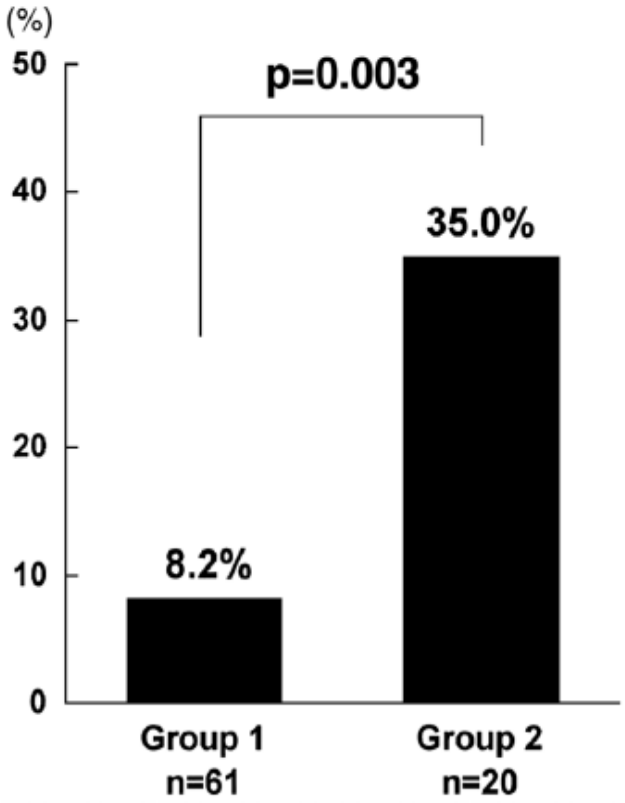




All pairs are significantly different in each segment, except for abcarinal vs. myocardial and epicardial vs. myocardial pairs in PV

# Plaque in the SB ostium

## Strong IVUS Predictors of SB Occlusion



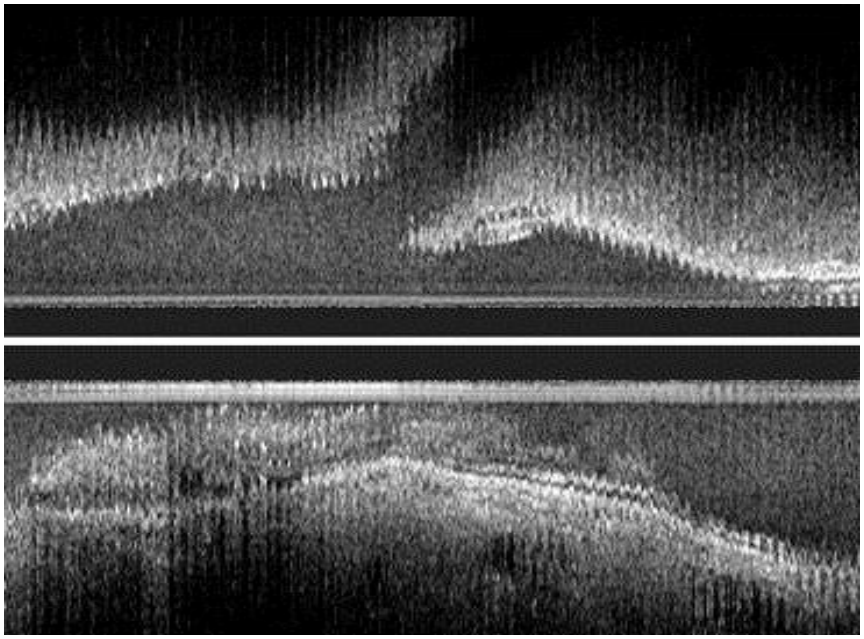




Furukawa, Circ J 2005

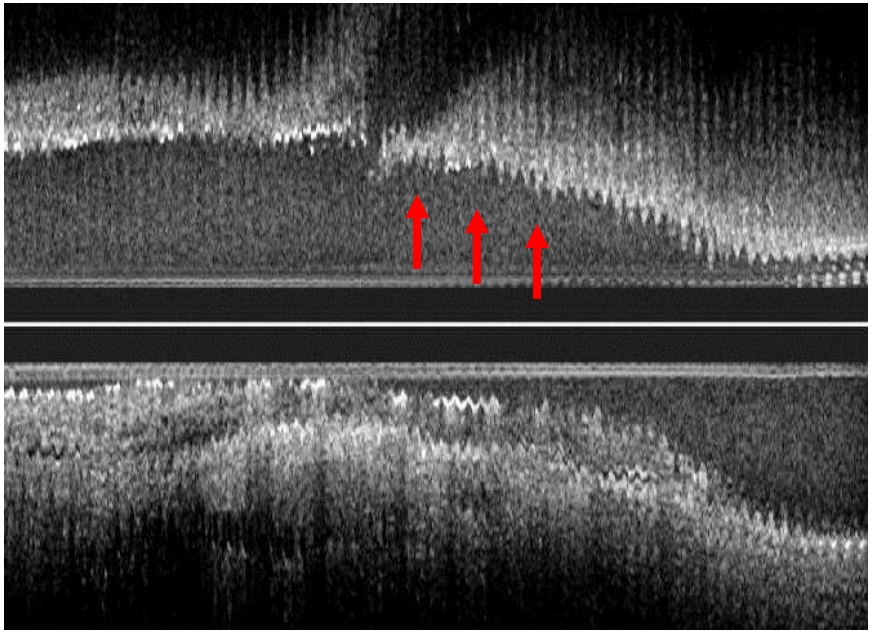
JCR 2011

# Carina Shift vs. Plaque Shift

Before stenting



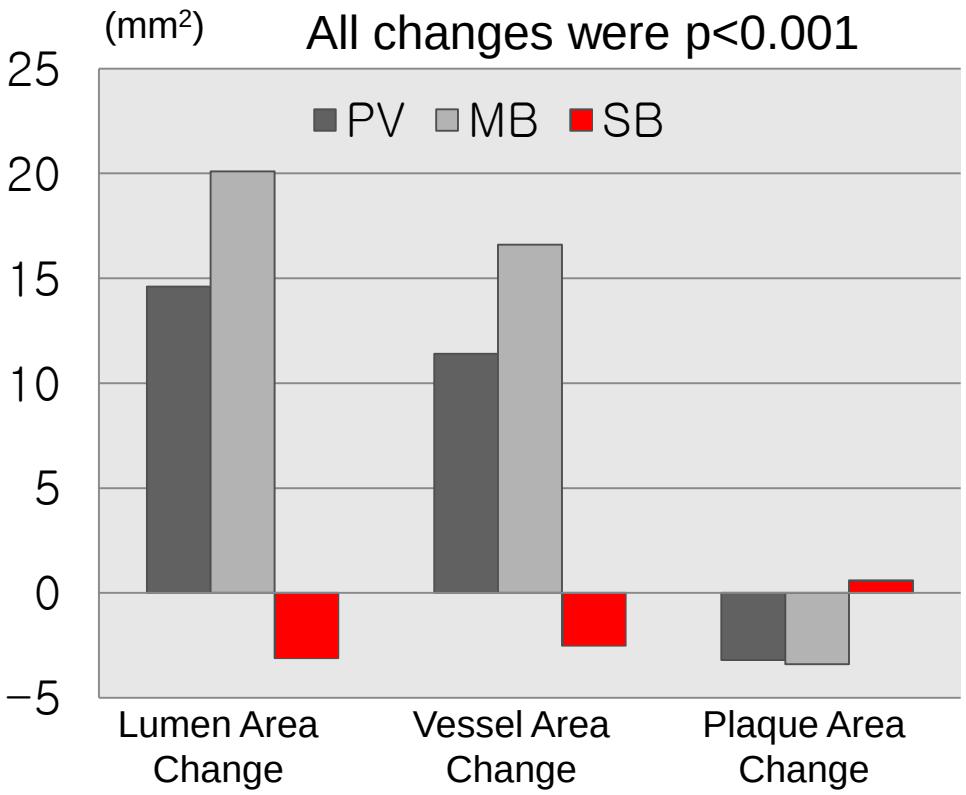
After stenting

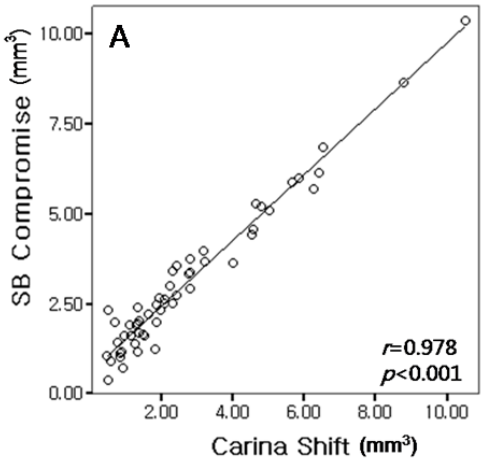


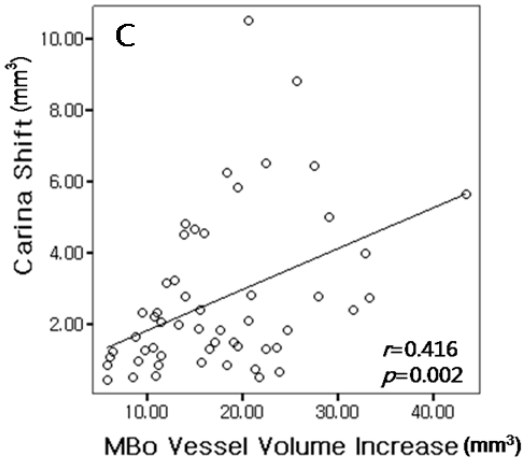
Stent over-expansion in the main branch increases the risk of SB occlusion, which can be reduced by IVUS-guided stent size selection.

# Carina Shift vs. Plaque Shift

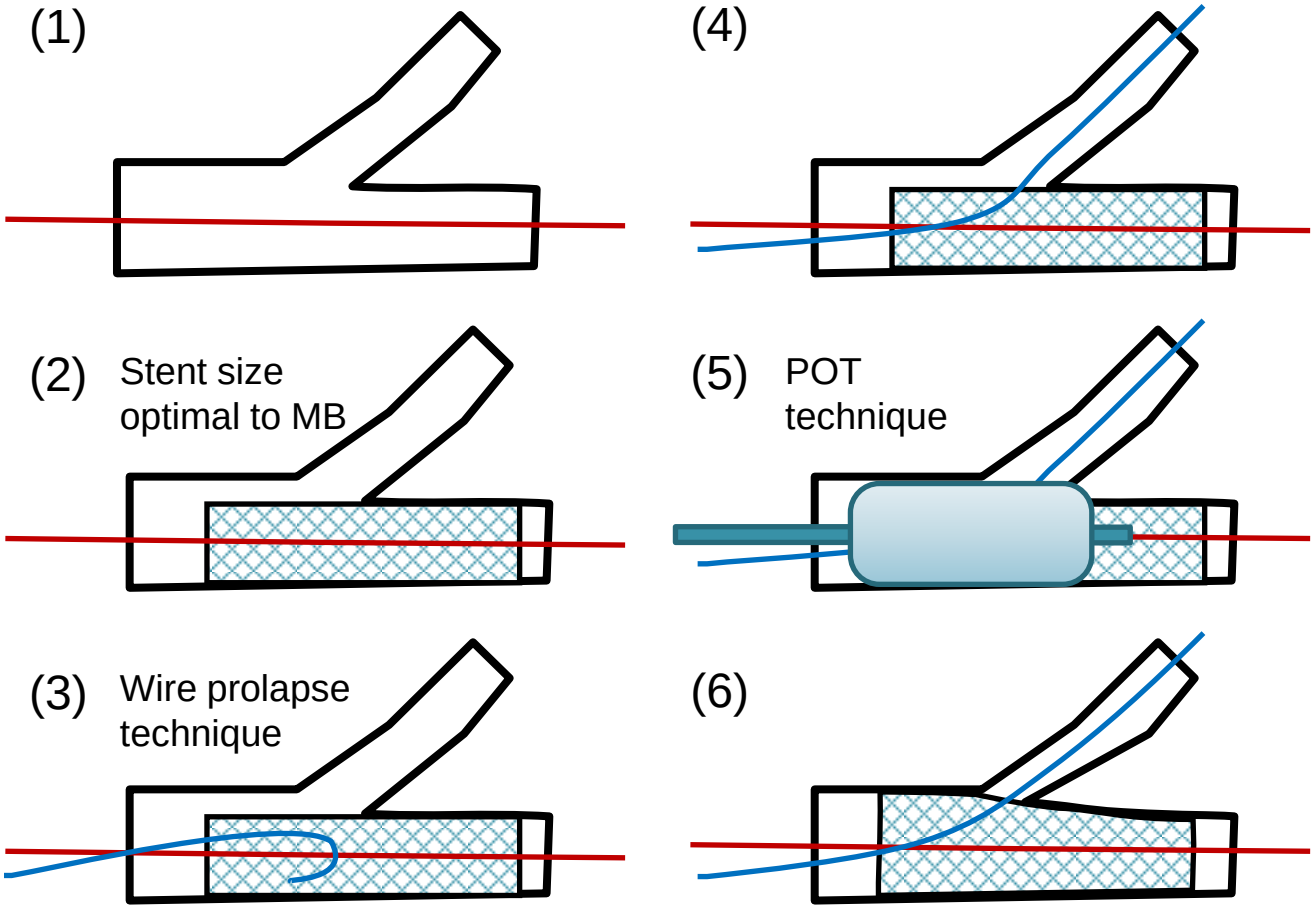
- N=49, IVUS in cross-over stenting
- Carina shift comprises **71%** of SB os compromise.



# My Strategy to Reduce SB Compromise



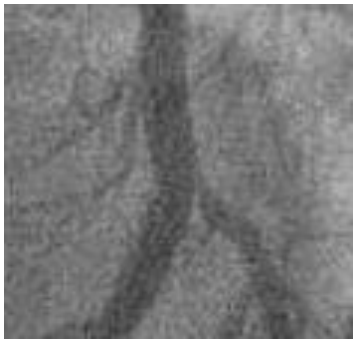
# Evaluation of SB Ostial Stenosis

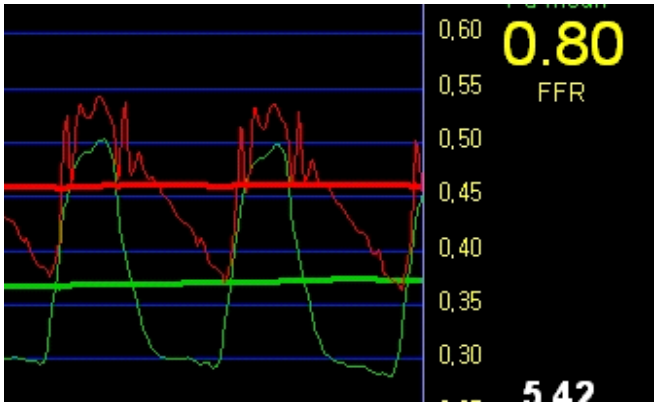
## Angiography is overestimating

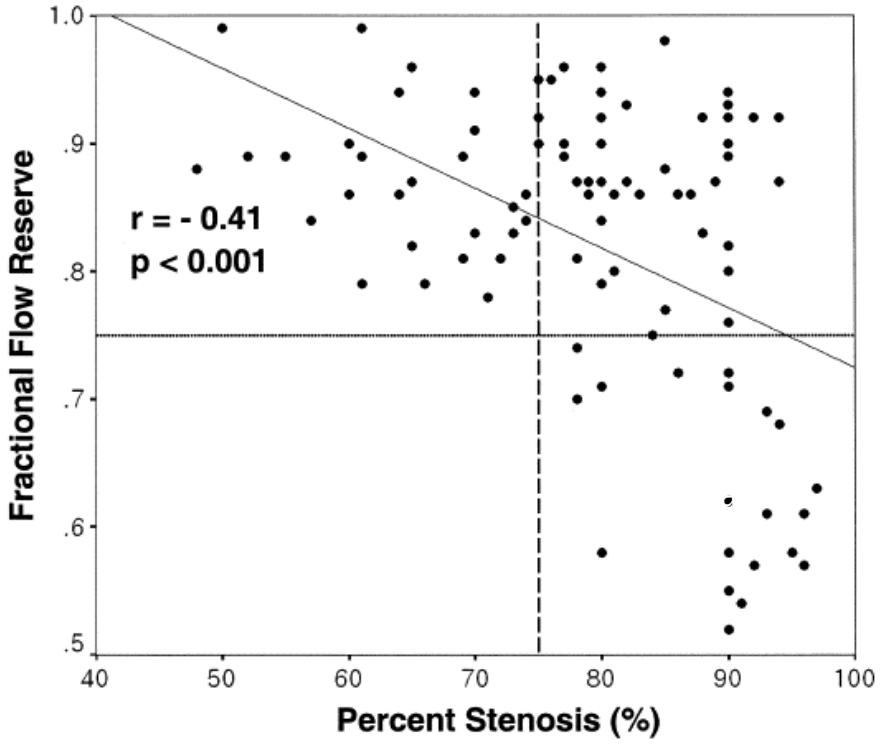


- In side branch, no lesion <75% stenosis was functionally significant.
- Among 73 lesions > 75% stenosis, 73% were functionally insignificant.

$$FFR = \frac{P_d}{P_a}$$



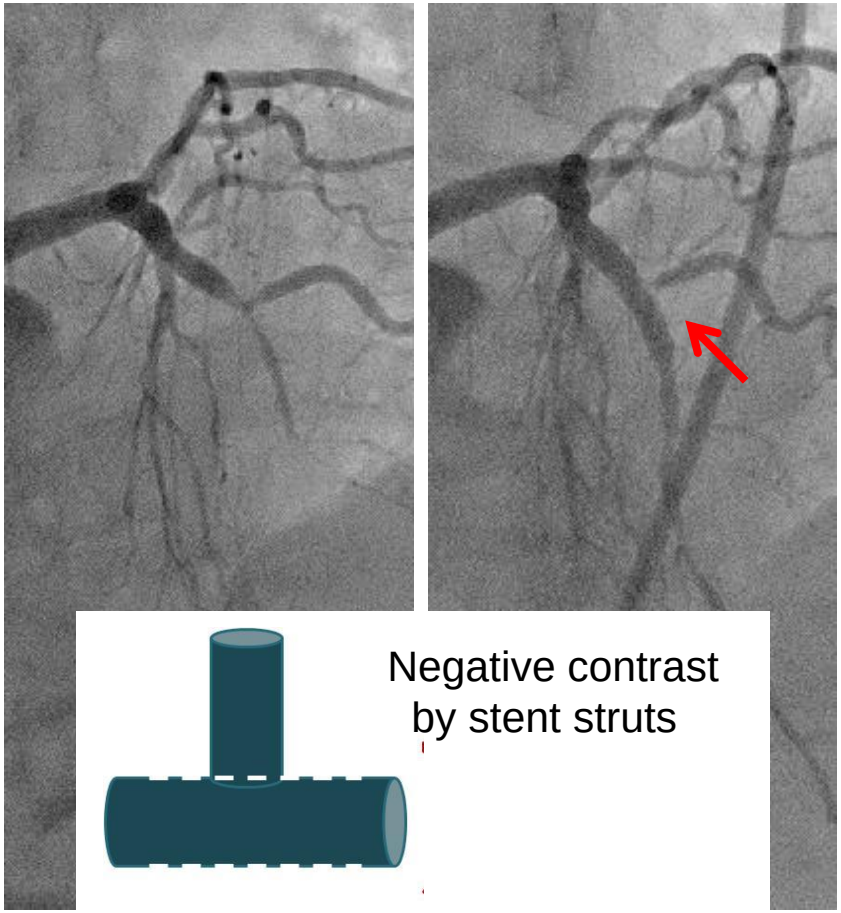


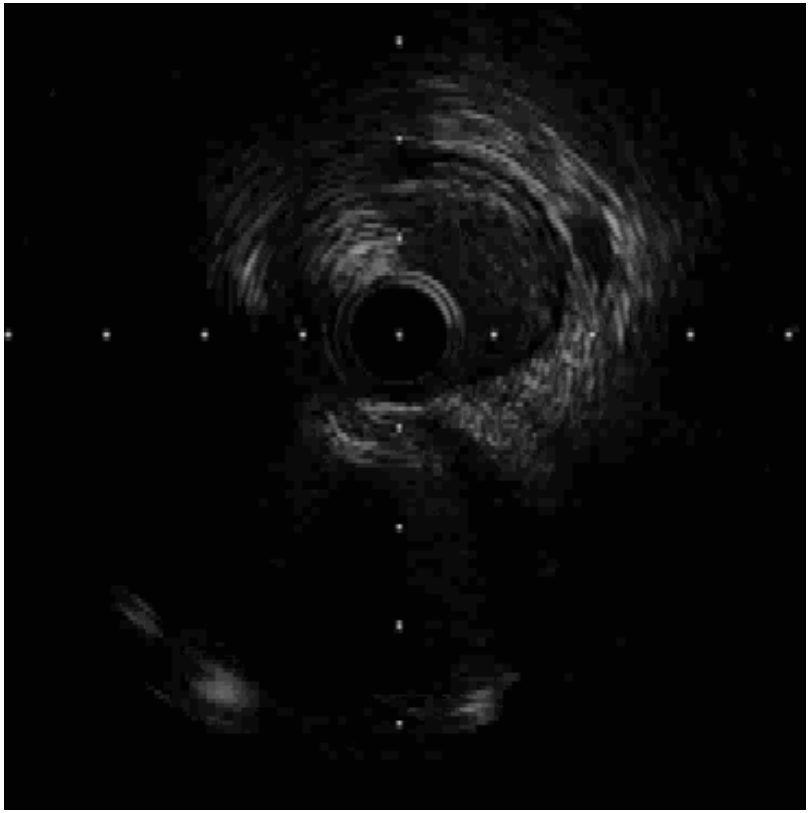
# Evaluation of SB Ostial Stenosis

## IVUS Helps





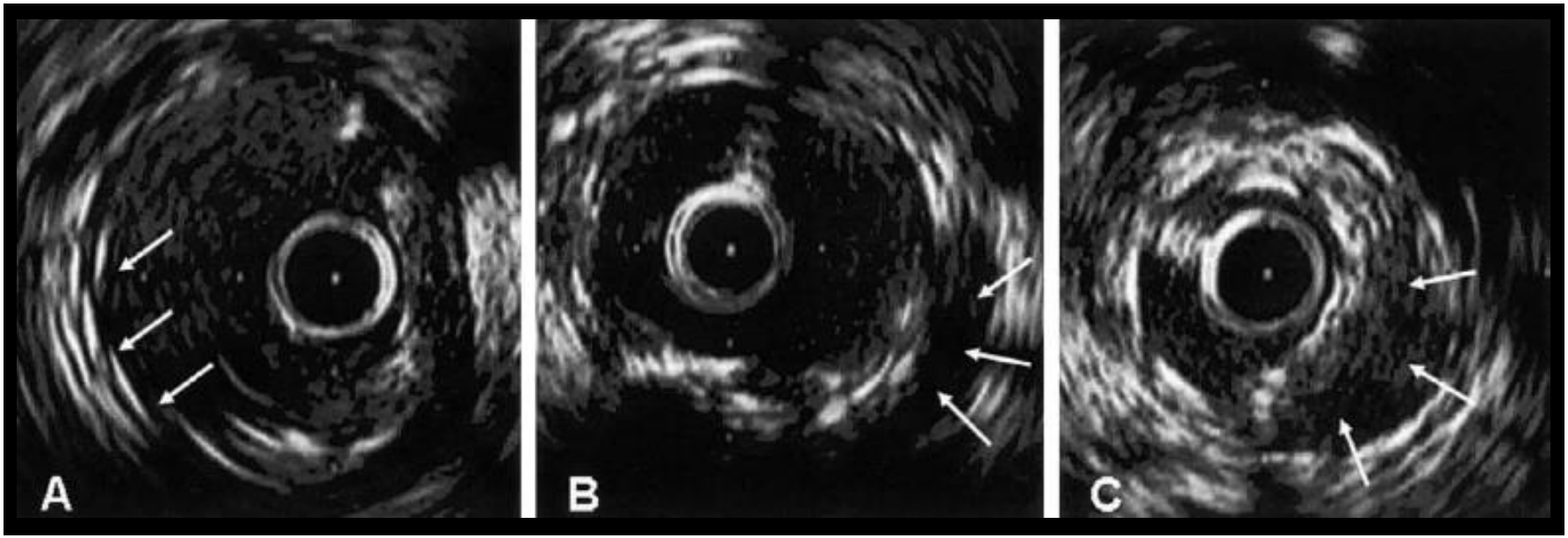

Baseline CAG  Stent crossover



Diagonal to LAD Pull-back

# Stent Expansion and Apposition
## Incomplete Crush Assessed by IVUS

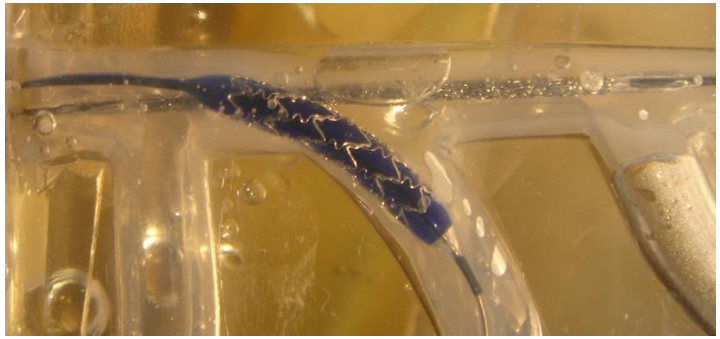
- Incomplete crushing in > 60% of non-left main lesions
- Minimal stent area in the crush area: 56%

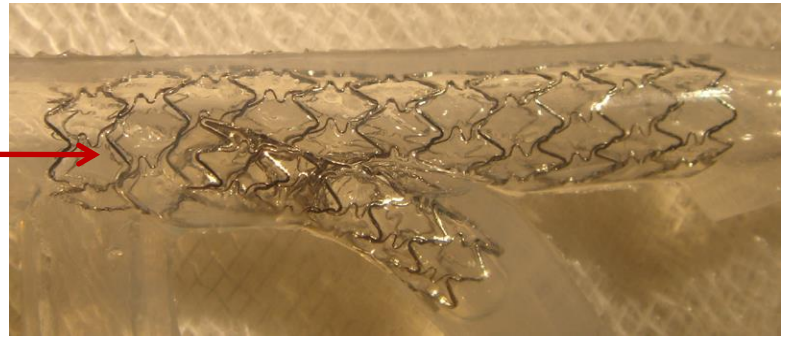


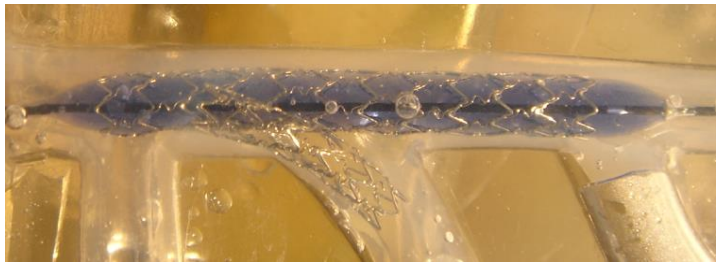

A) Complete crush, B) 3-layers struts, C) Incomplete crush

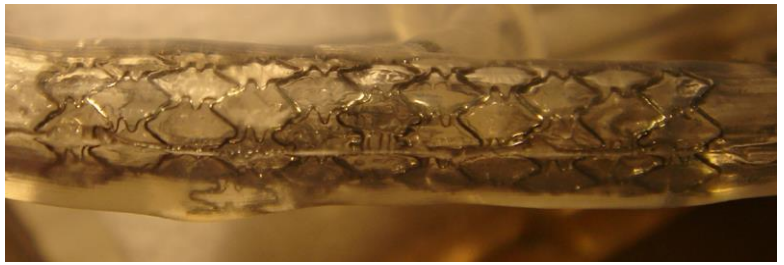
# Stent Expansion and Apposition

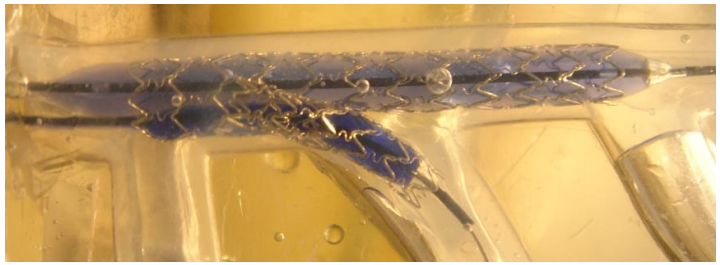
## Stent may not be crushed by crush technique

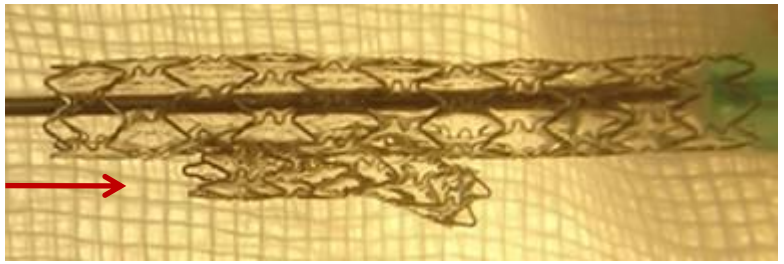












# Crushing was improved in DK Crush Technique

Serial IVUS Analysis Comparing Double Kissing (DK) and Classical Crush Stenting for Coronary Bifurcation Lesions

| | Classical Crush (N=16) | DK Crush (N=38) | P-value |
|---|---|---|---|
| Incomplete crush, | 81.3% | 39.5% | p=0.004 |
| Unsatisfactory kissing* | 62.5% | 18.0% | p<0.001 |
| Post-stenting symmetry | 72±8% | 86±6% | p=0.022 |
| Neointimal hyperplasia ($mm^2$) | 1.60±0.21 | 0.85±0.23 | p=0.005 |
| Late lumen loss ($mm^2$) | 1.31±0.81 | 0.55±0.70 | p=0.013 |
| Side branch MLA ($mm^2$) | 3.57±1.52 | 4.52±1.40 | p=0.042 |

~~* defined as the presence of wrist or >20% stenosis during FKBI at the SB~~ ostium

Chen S, Catheter Cardiovasc Interv 2011

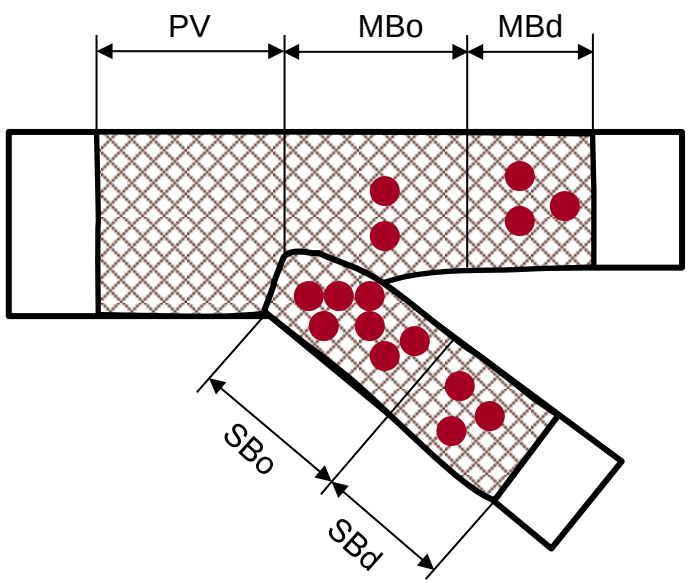
JCR 2011

# Stent Expansion in Side Branch

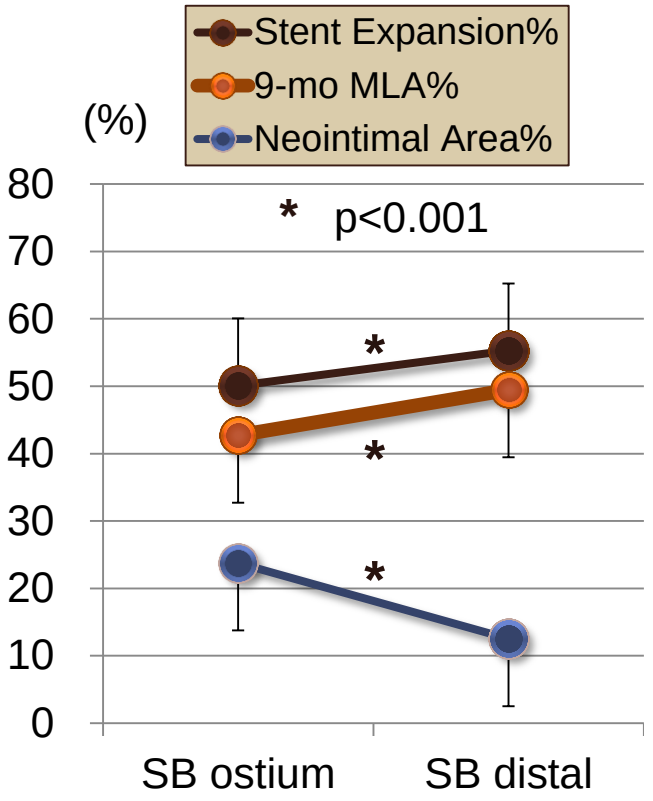
## SB ostium is the most frequent location of restenosis

Mechanisms are stent under-expansion and neointimal proliferation.

**Restenosis Location**




in Two stent TAP Technique (N=73)




Hahn JY, Gwon HC, JACC 2009

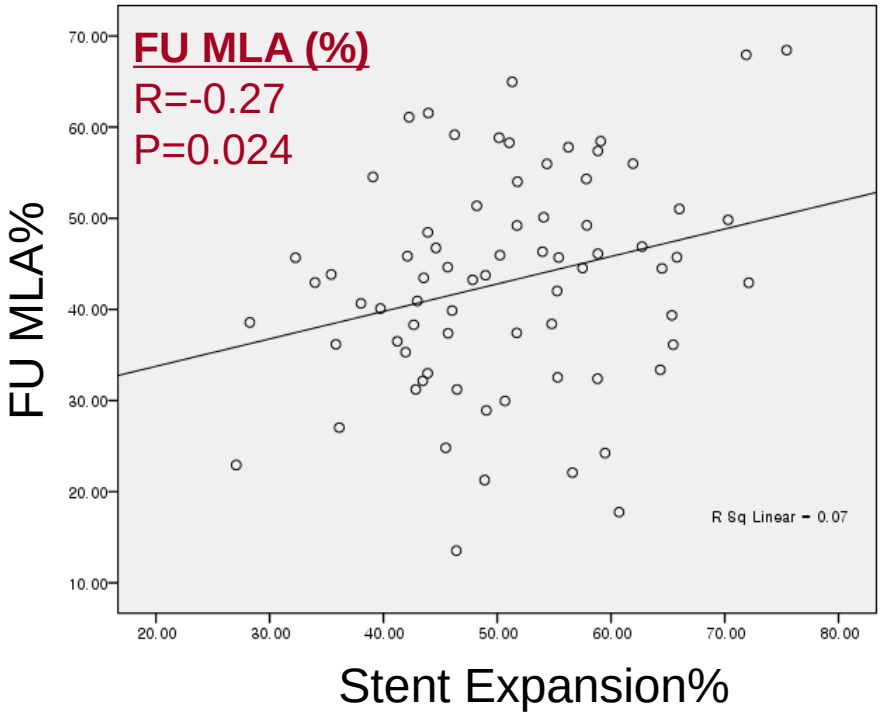
JCR 2011

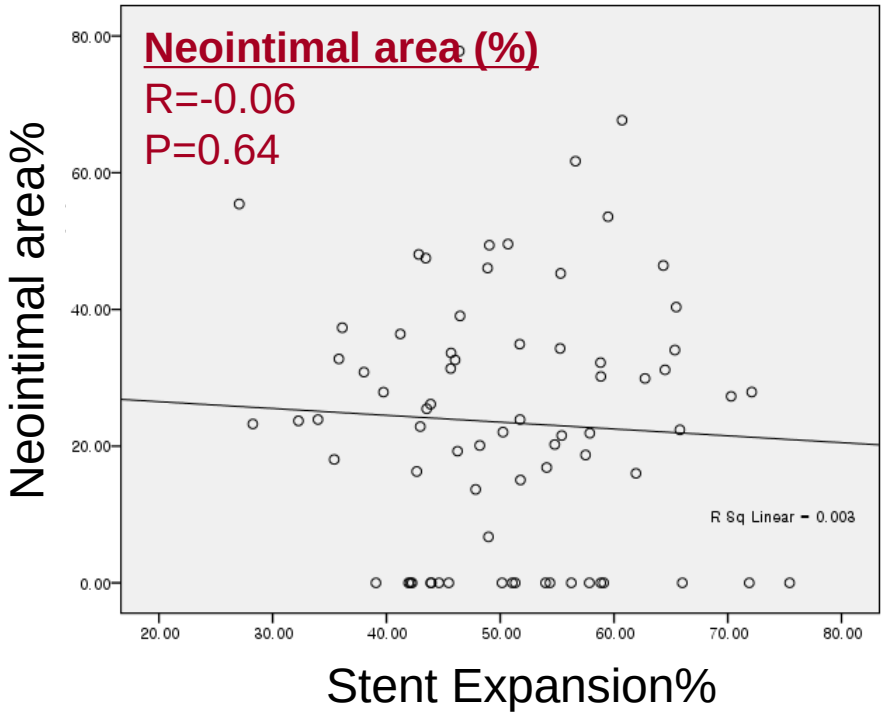
# Stent Expansion in Side Branch

## SB ostium is the most frequent location of restenosis

Better stent expansion improved FU minimal luminal area in SB ostium without an increase of neointimal proliferation.

**Impact of Stent expansion**




Hahn JY, Gwon HC, JACC 2009

JCR 2011

# Optimal Cutoff Value of Post-procedural MSA

- 4.8 $mm^2$ for SB, 5.8 $mm^2$ for MV

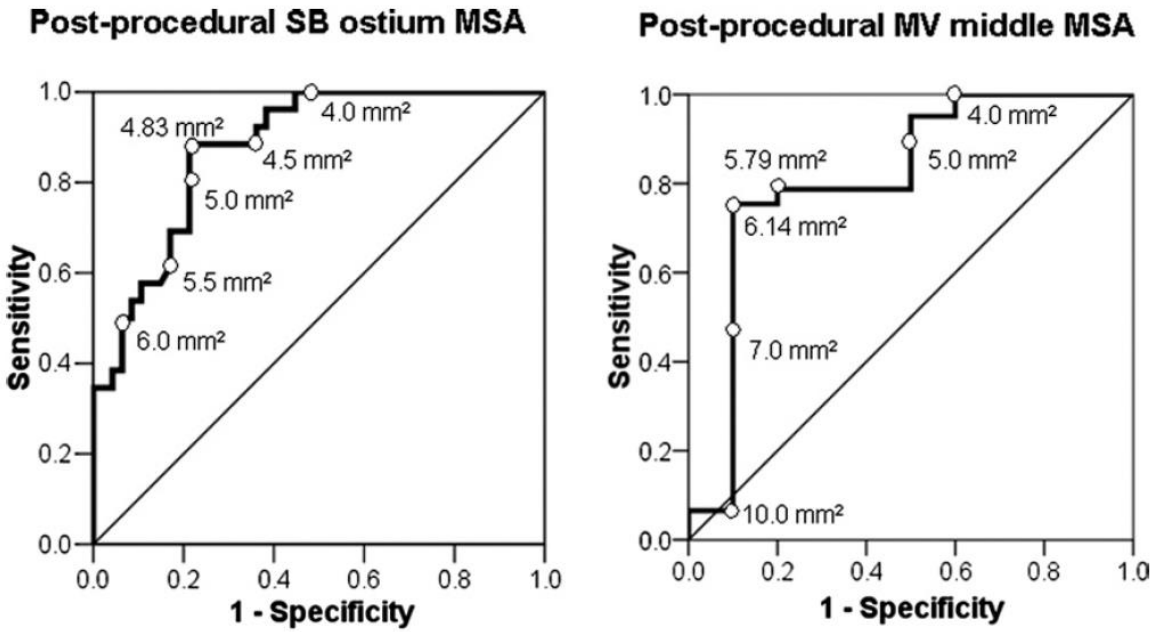
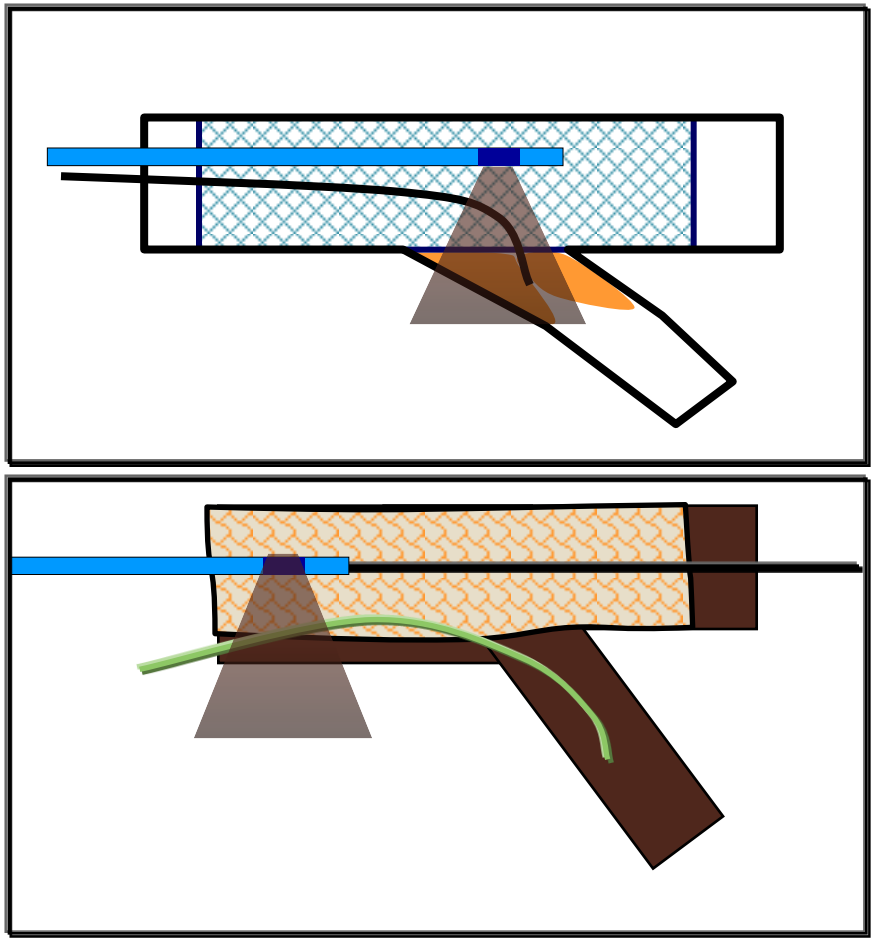



**Figure 6** **The Optimal Cutoff Value of Post-Procedural MSA**

The receiver-operator characteristic curve showing the optimal cutoff value of post-procedural minimum stent area (MSA) at the SB ostium **(A)** and at the MV middle area **(B)** to predict adequate follow-up minimum luminal area. Abbreviations as in Figure 3.

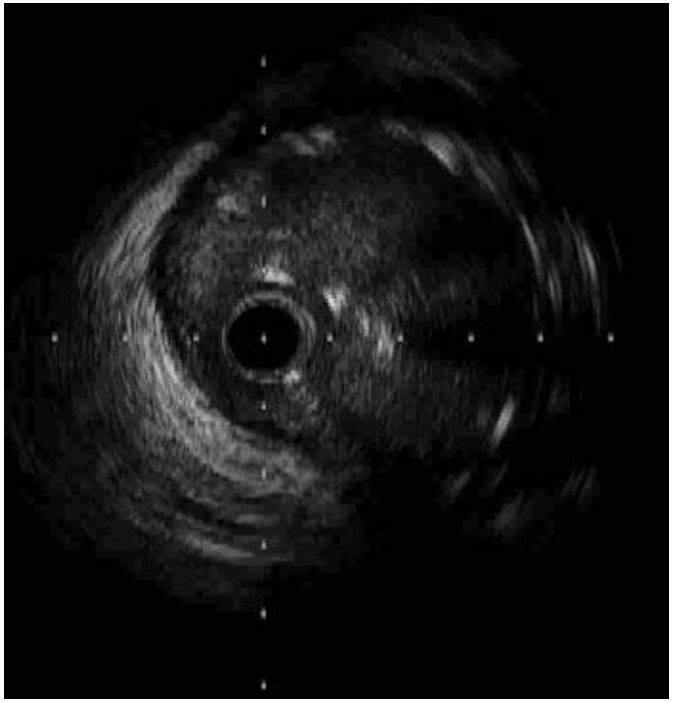
# IVUS-Guided Bailout Maneuvers

- IVUS guidance for the access to an occluded side branch
- IVUS guidance to avoid the wire undermining



# IVUS-Guided Bailout Maneuvers

## Wire Undermining



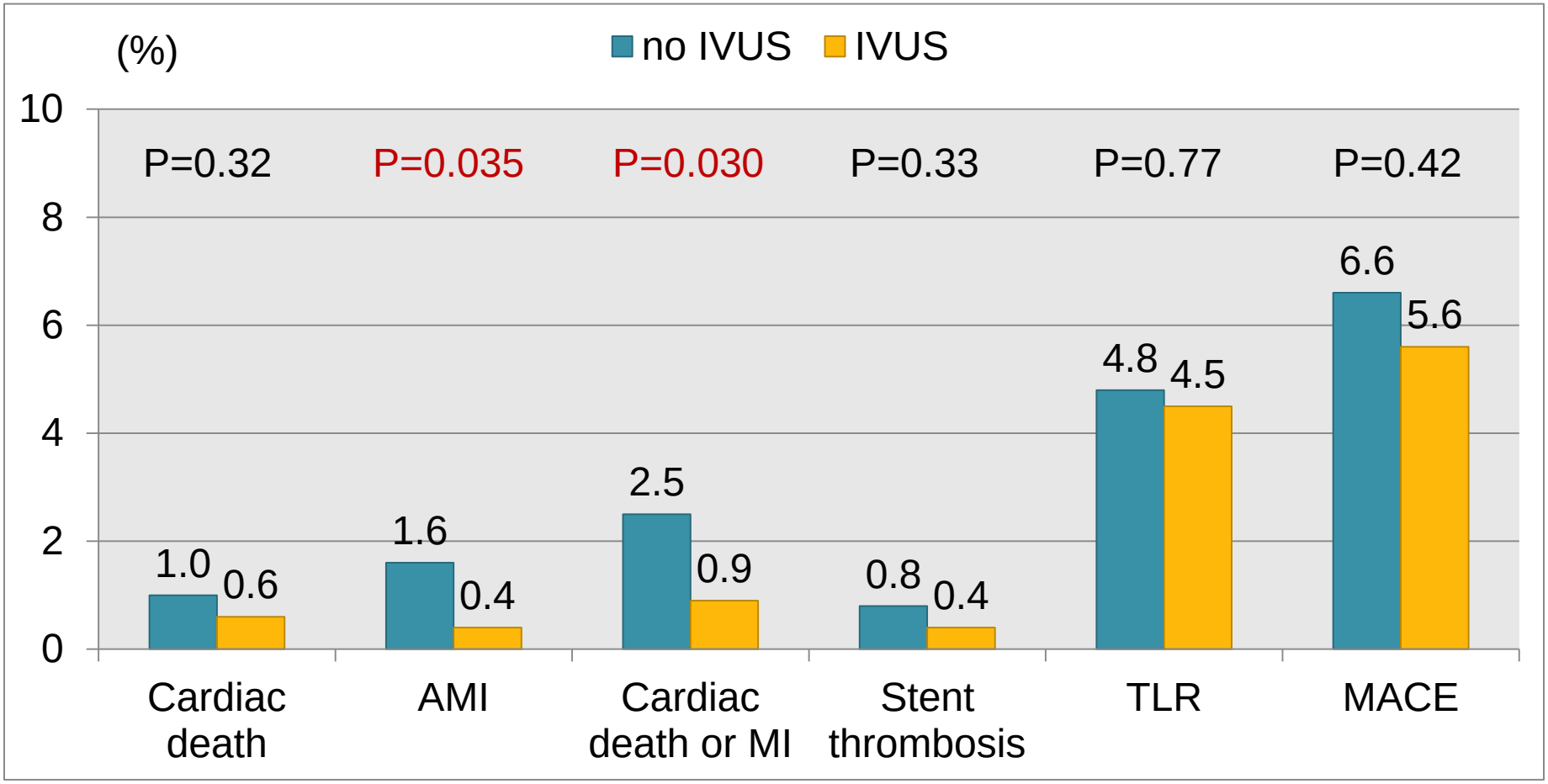
Pullback from LCX to LM after kissing ballooning, IVUS undermines the LM Stent

# IVUS Guidance May Improve Safety in Bifurcation Stenting

Samsung Medical Center
Cardiac & Vascular Center

SMC

## COBIS Registry N=1668, Median FU 22.4 months




Kim JS, Am Heart J 2011

JCR 2011

# Summary and Conclusion

- The role of IVUS during bifurcation stenting: a practical and research tool
  - Predicting complication — **SB occlusion**
  - Procedure guidance — **SB rewiring**
  - Treatment strategy
    - Device selection — **Low late loss**
    - Optimizing the results — **Balloon Pressure**