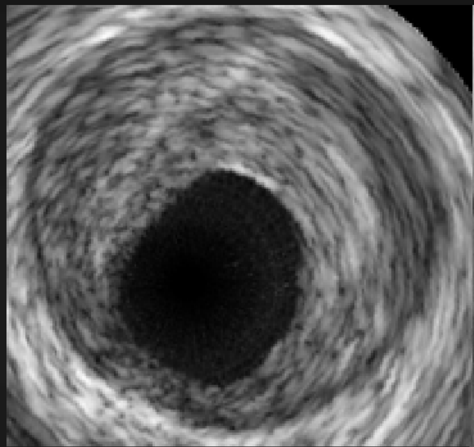
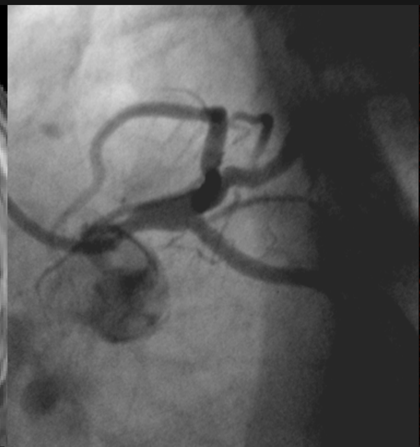
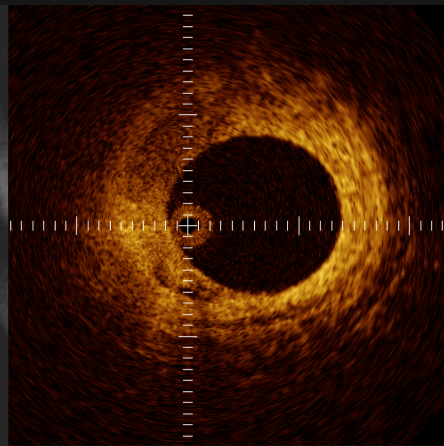
# Left Main PCI

## Dedicated techniques, stents, and operators


**Ran Kornowski, MD, FACC, FESC**

**Rabin Medical Center and Tel Aviv University, Israel**



Coronary Catheterization Course – December 16, 2011

# LM PCI: Why is it such a big issue?

- Because…
  - It is prognostic significant (not just symptoms)
  - the myocardial jeopardy is extensive and does not leave much room for fault consequences.
  - it can be technically challenging.
  - it demands proper planning and substantial expertise.
  - it operates within the ‘dark gray zone’ of current revascularization guidelines.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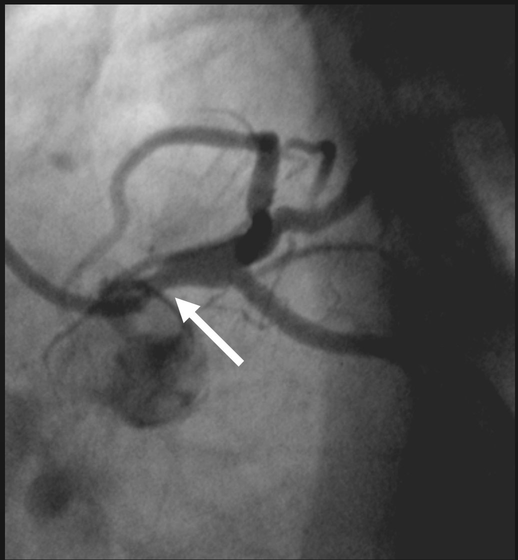
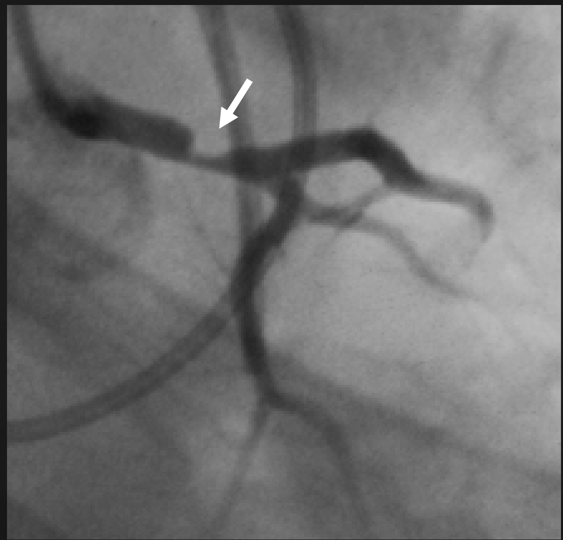
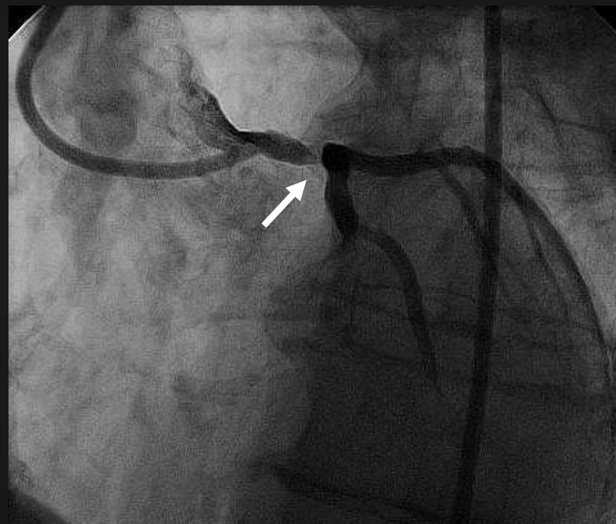
# Anatomic variations



Ostial stenosis



Mid shaft stenosis

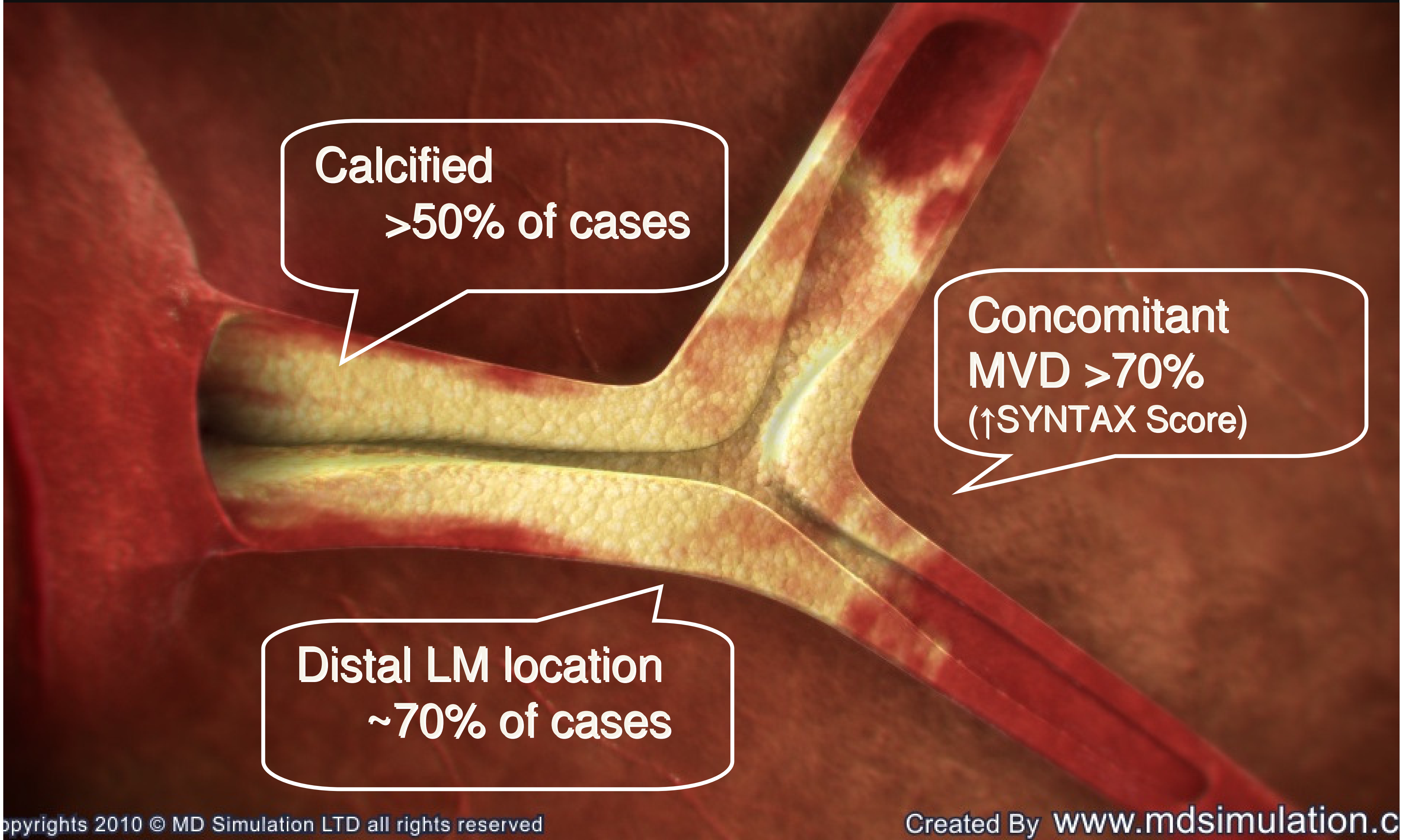


Distal stenosis

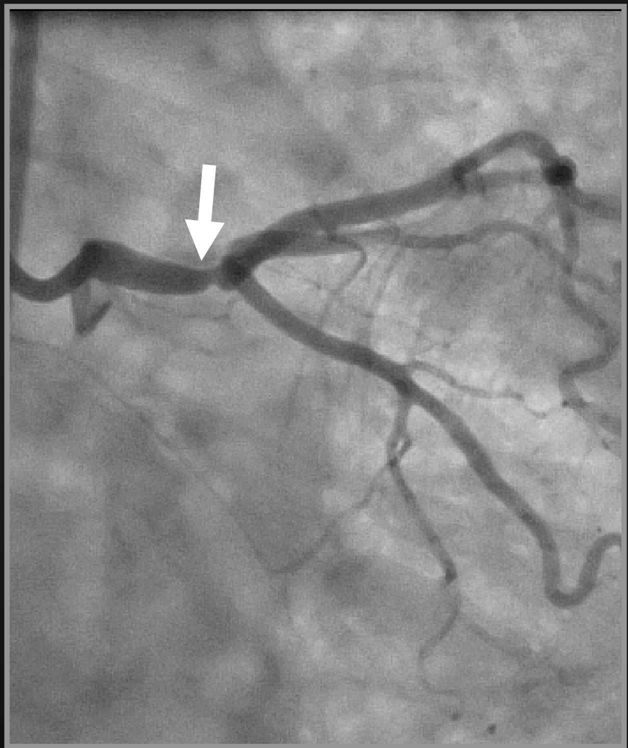
# Impact on prognosis

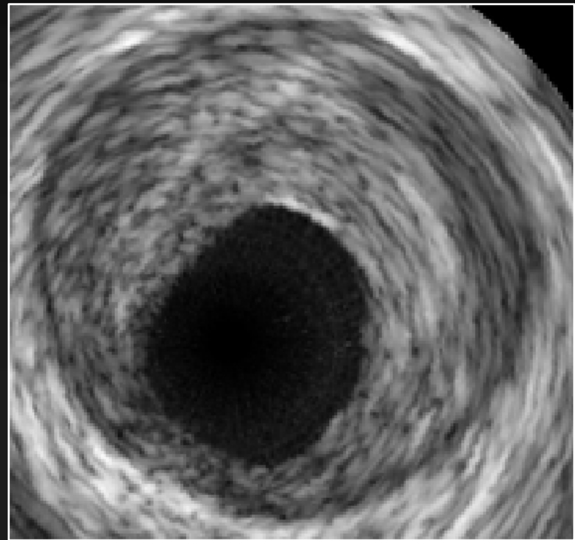
- Co-Morbidity
  - Elderly patient
  - LV Function
  - Associated valvular pathology
  - Emergent presentation
  - Shock
  - Diabetes mellitus
  - Renal dysfunction
  - EuroScore, STS Score
  - SYNTAX Score

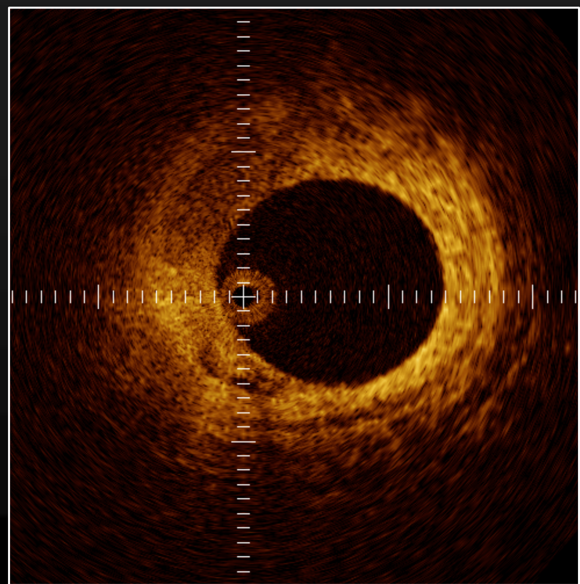
# Left main complexities

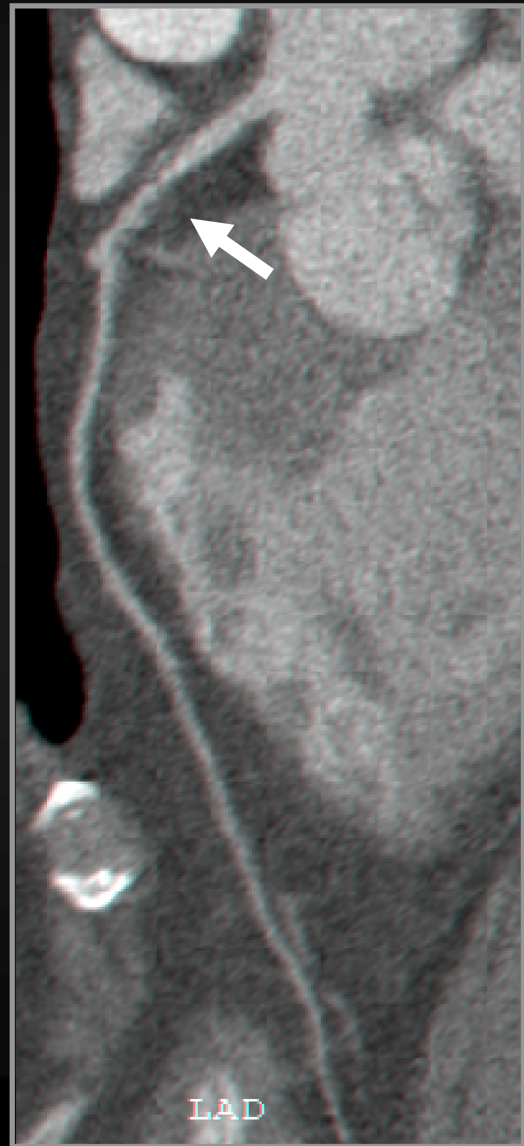


# Left Main assessment: *Imaging Modalities*

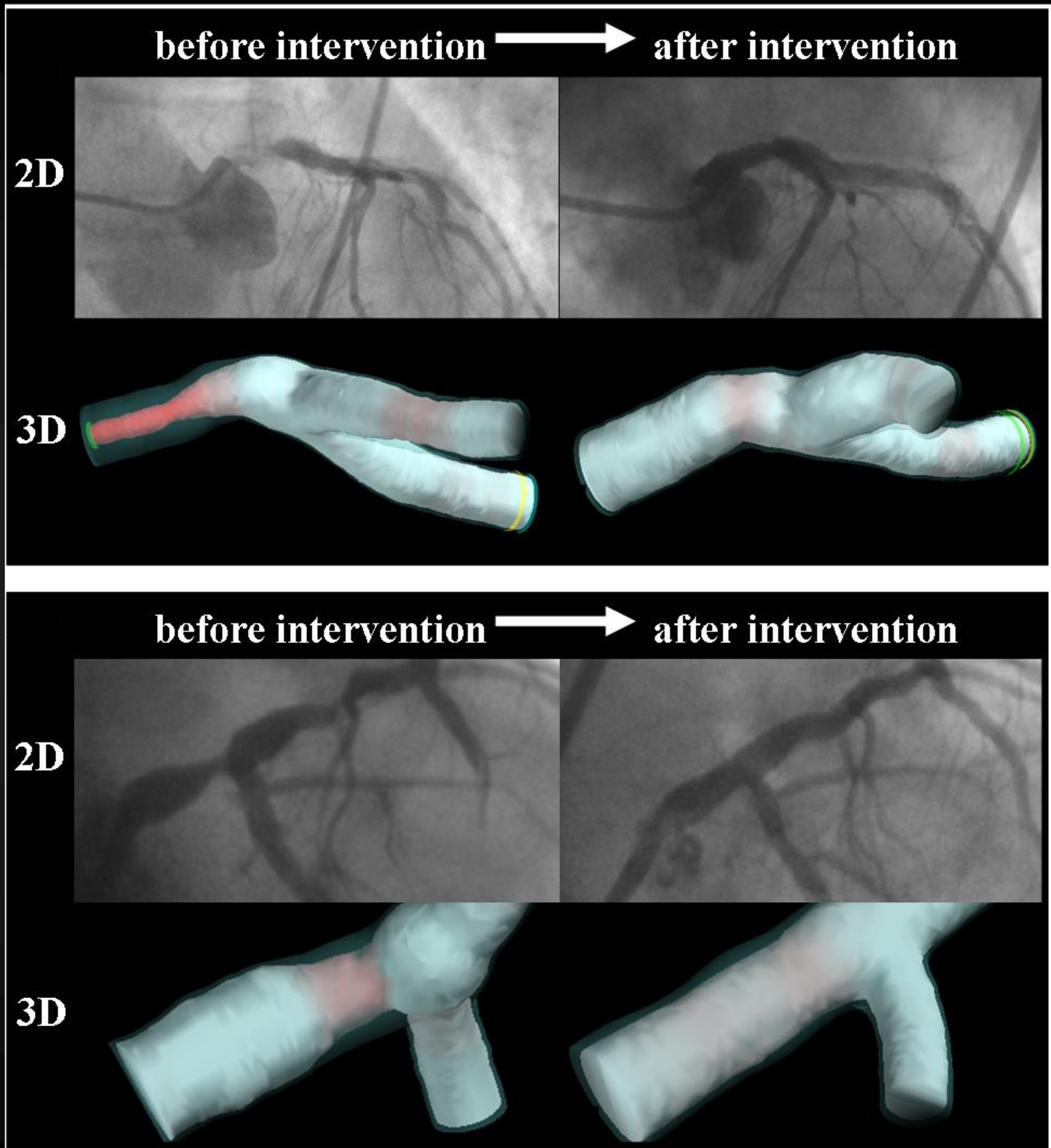








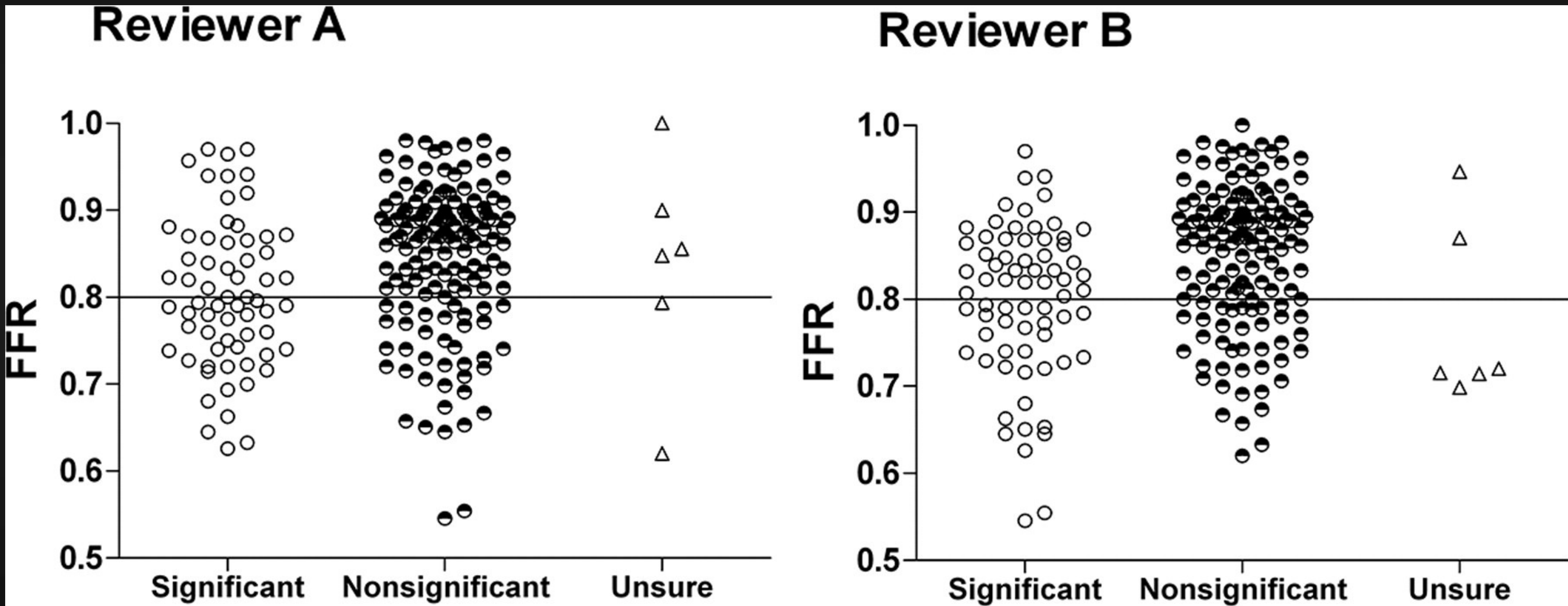
# Left Main 3D Angio




Dvir D, …Kornowski R, Cardiovasc Revasc Med (in press)

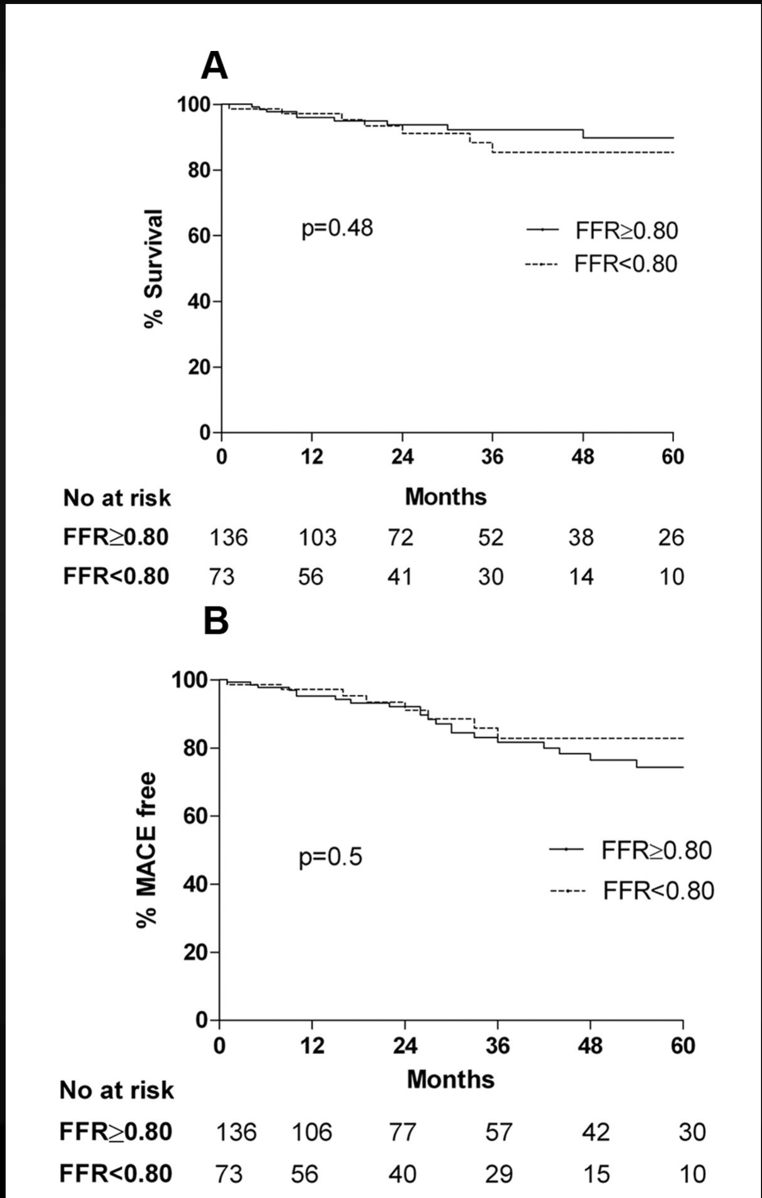
# FFR in LMCA Stenosis Assessment

**Relation between FFR values and the 2 reviewers' visual estimations (lesions were classified as significant, nonsignificant, and unsure).**




Hamilos M et al. Circulation 2009;120:1505-1512

# FFR in LMCA Stenosis Assessment




**Kaplan–Meier mortality curves showing percent survival (A) and major adverse cardiac events (MACE; B) in the 2 study groups.**

**Hamilos M et al.**
**Circulation 2009;120:1505-1512**

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doi:10.1016/j.jacc.2011.06.066

**Cardiac Imaging**

# Diagnosis of Ischemia-Causing Coronary Stenoses by Noninvasive Fractional Flow Reserve Computed From Coronary Computed Tomographic Angiograms

## Results From the Prospective Multicenter DISCOVER-FLOW (Diagnosis of Ischemia-Causing Stenoses Obtained Via Noninvasive Fractional Flow Reserve) Study

Bon-Kwon Koo, MD, PHD,* Andrejs Erglis, MD, PHD,† Joon-Hyung Doh, MD, PHD,‡ David V. Daniels, MD,§ Sanda Jegere, MD,‖ Hyo-Soo Kim, MD, PHD,* Allison Dunning, MD,¶ Tony DeFrance, MD,# Alexandra Lansky, MD,** Jonathan Leipsic, BSc, MD,†† James K. Min, MD‡‡

*Seoul and Goyang, South Korea; Riga, Latvia; Palo Alto, San Francisco, and Los Angeles, California; New York, New York; New Haven, Connecticut; and Vancouver, British Columbia, Canada*

**Objectives** The aim of this study was to determine the diagnostic performance of a new method for quantifying fractional flow reserve (FFR) with computational fluid dynamics (CFD) applied to coronary computed tomography angiography (CCTA) data in patients with suspected or known coronary artery disease (CAD).

**Background** Measurement of FFR during invasive coronary angiography is the gold standard for identifying coronary artery lesions that cause ischemia and improves clinical decision-making for revascularization. Computation of FFR from CCTA data ($FFR_{CT}$) provides a noninvasive method for identifying ischemia-causing stenosis; however, the diagnostic performance of this new method is unknown.

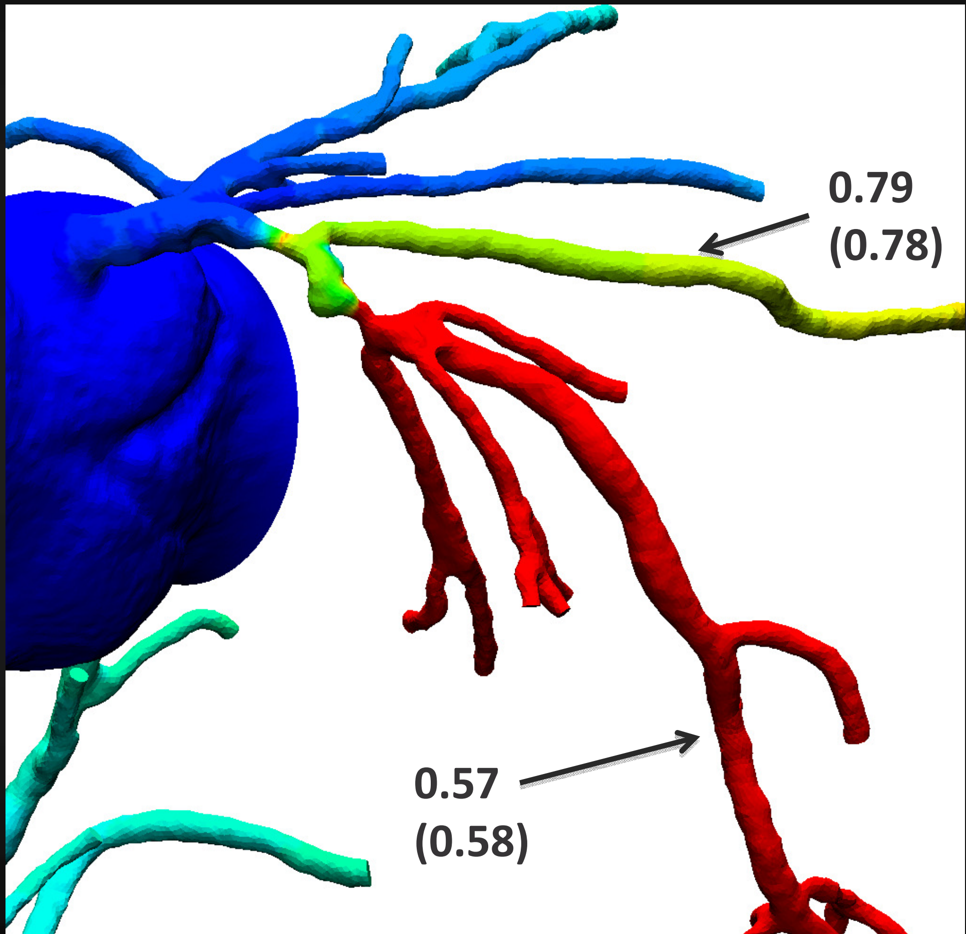
**Methods** Computation of FFR from CCTA data was performed on 159 vessels in 103 patients undergoing CCTA, invasive coronary angiography, and FFR. Independent core laboratories determined $FFR_{CT}$ and CAD stenosis severity by CCTA. Ischemia was defined by an $FFR_{CT}$ and FFR $\leq$0.80, and anatomically obstructive CAD was defined as a CCTA with stenosis $\geq$50%. Diagnostic performance of $FFR_{CT}$ and CCTA stenosis was assessed with invasive FFR as the reference standard.

**Results** Fifty-six percent of patients had $\geq$1 vessel with FFR $\leq$0.80. On a per-vessel basis, the accuracy, sensitivity, specificity, positive predictive value, and negative predictive value were 84.3%, 87.9%, 82.2%, 73.9%, 92.2%, respectively, for $FFR_{CT}$ and were 58.5%, 91.4%, 39.6%, 46.5%, 88.9%, respectively, for CCTA stenosis. The area under the receiver-operator characteristics curve was 0.90 for $FFR_{CT}$ and 0.75 for CCTA ($p = 0.001$). The $FFR_{CT}$ and FFR were well correlated ($r = 0.717$, $p < 0.001$) with a slight underestimation by $FFR_{CT}$ ($0.022 \pm 0.116$, $p = 0.016$).

**Conclusions** Noninvasive FFR derived from CCTA is a novel method with high diagnostic performance for the detection and exclusion of coronary lesions that cause ischemia. (The Diagnosis of ISChemia-Causing Stenoses Obtained Via NoninvasivE FRactional FLOW Reserve; NCT01189331) (J Am Coll Cardiol 2011;58:1989–97) © 2011 by the American College of Cardiology Foundation

JACC Nov 1st, 2011

# HeartFlow™ Imaging: Combining Cardiac CTA +FFR




Images courtesy of Bon Kwon Koo, MD

# Fundamental issues

- CABG vs. PCI
- Procedural safety and effectiveness
- PCI planning is mandatory
- Long-term consequences

# Favorable vs. Unfavorable LMD for PCI

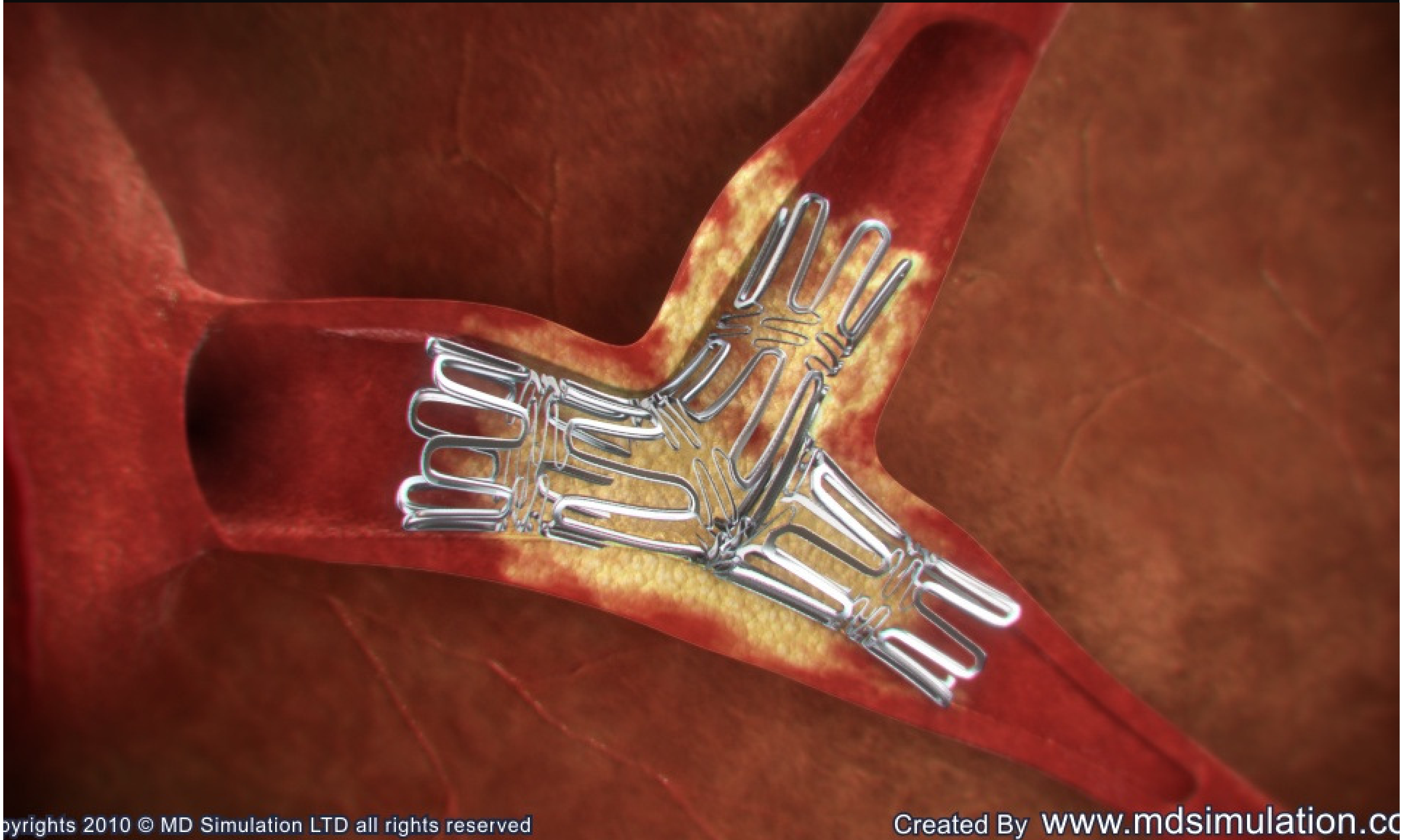
## Favorable for PCI

- Ostial LMD
- Mid shaft LMD
- Isolated LMD
- LM diameter ≥ 3.5mm
- Patent RCA
- No/mildly calcified
- Good LV function

## Problematic for PCI

- Distal LM
- Ostial LAD/LCX involvement
- Sharp LAD/LCX angles
- Heavy calcification
- LM diameter < 3.5 mm
- Associated MVD
- Occluded RCA
- Poor LV function
- Associated valve pathology

# PCI Strategies

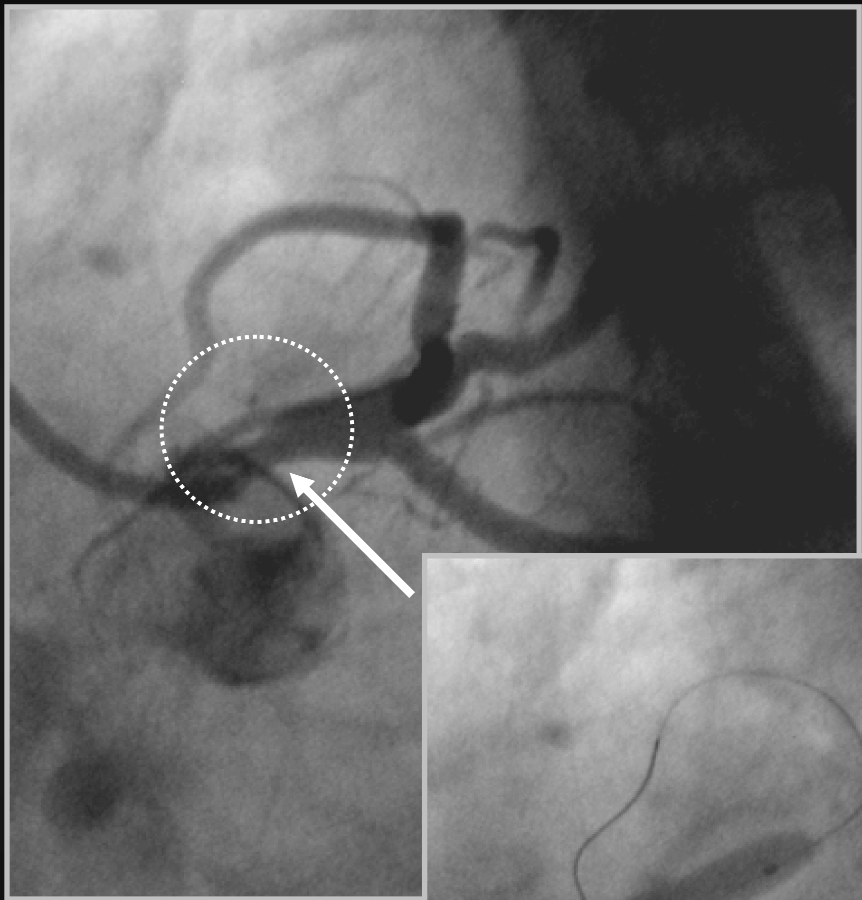


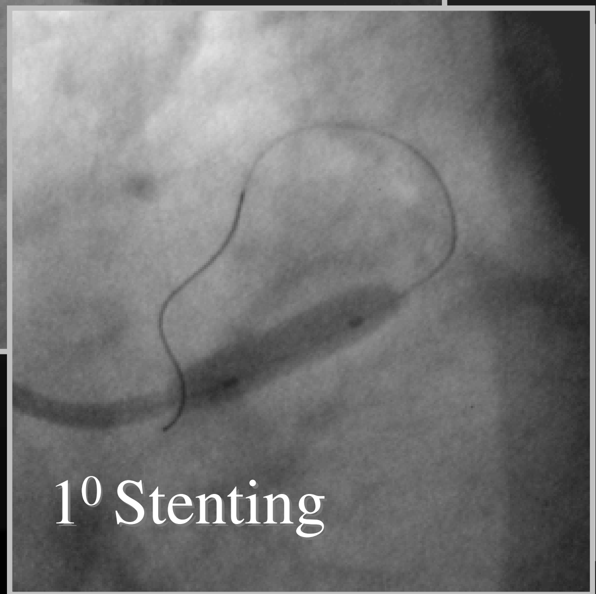
# PCI Considerations in Left Main PCI

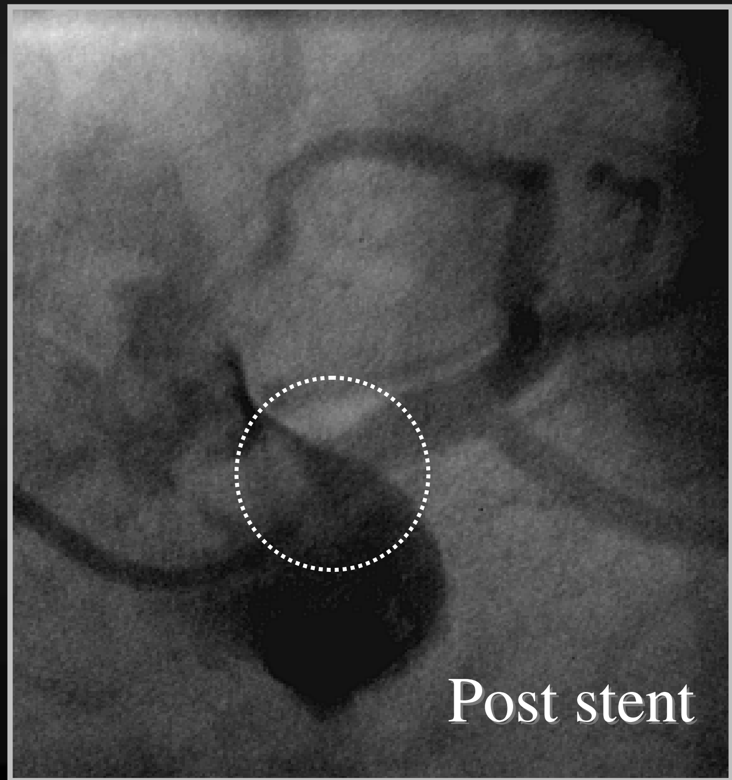
- Strategies in PCI
  - Direct vs. Non-direct stenting
  - Need for lesion debulking (+/-)
  - Bifurcation techniques
- Adjunctive technologies
  - Intravascular ultrasound
  - Directional or Rotational atherectomy
  - DES vs. BMS
- Late outcome
  - Long-term Clopidogrel or Prasugrel or Ticagrelor administration
  - Repeat angiography or cardiac CTA

# Ostial LM Stenting

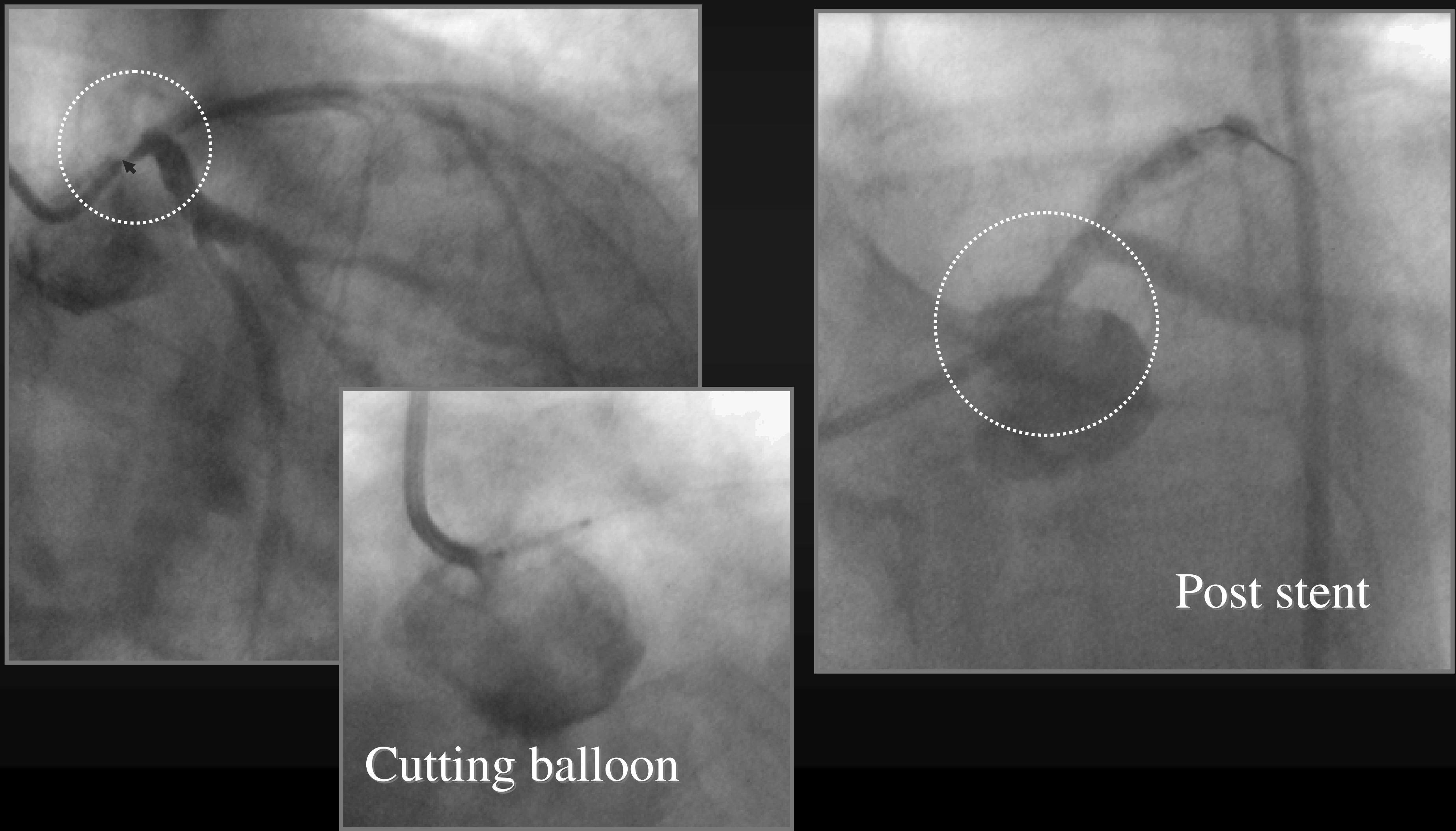
- Debulking or cutting?
  - Calcification
- Stent positioning
- DES vs. BMS?
- Optimal expansion
  - ➢IVUS Guidance



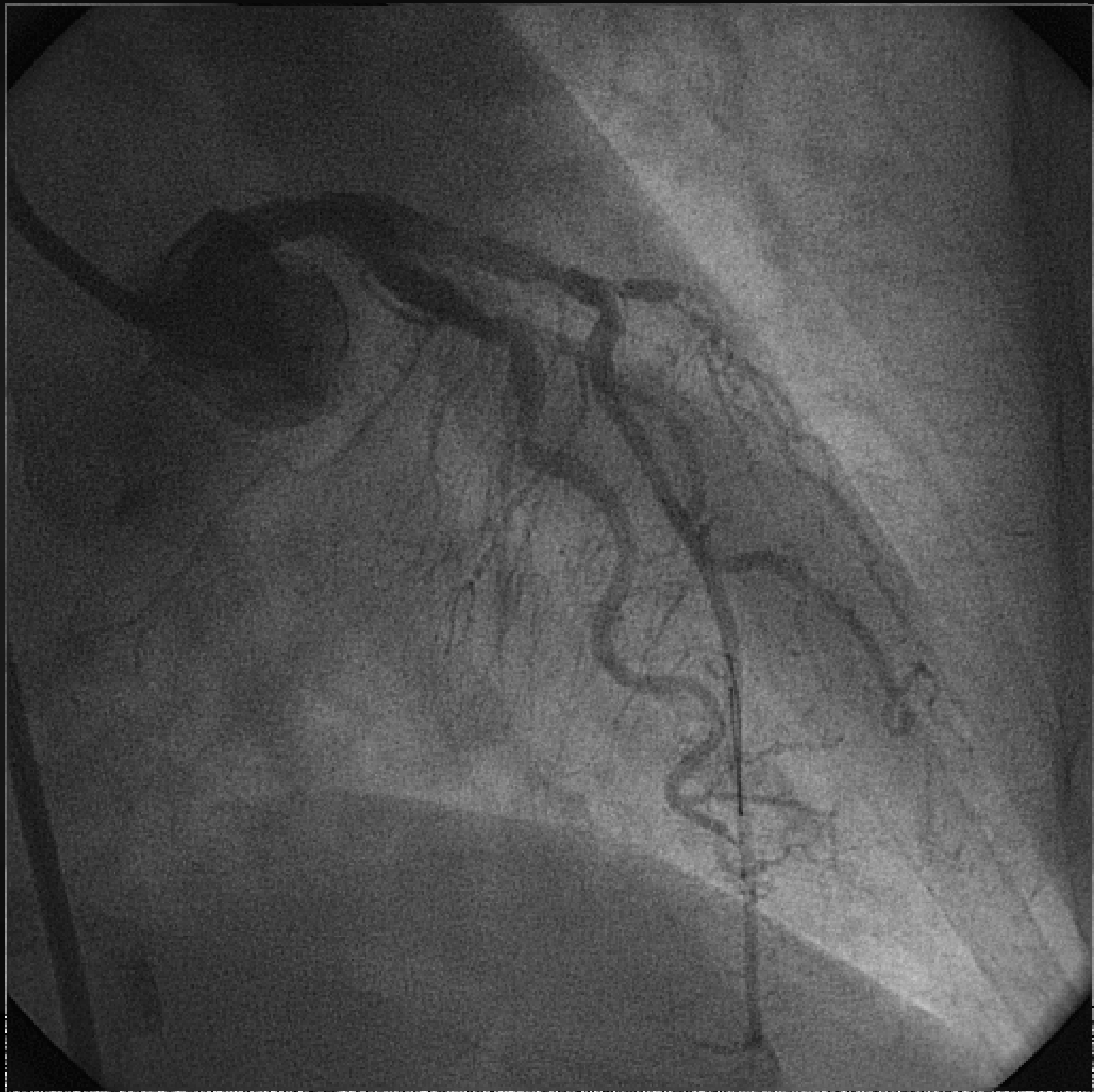


# Ostial and mid LM Stenting



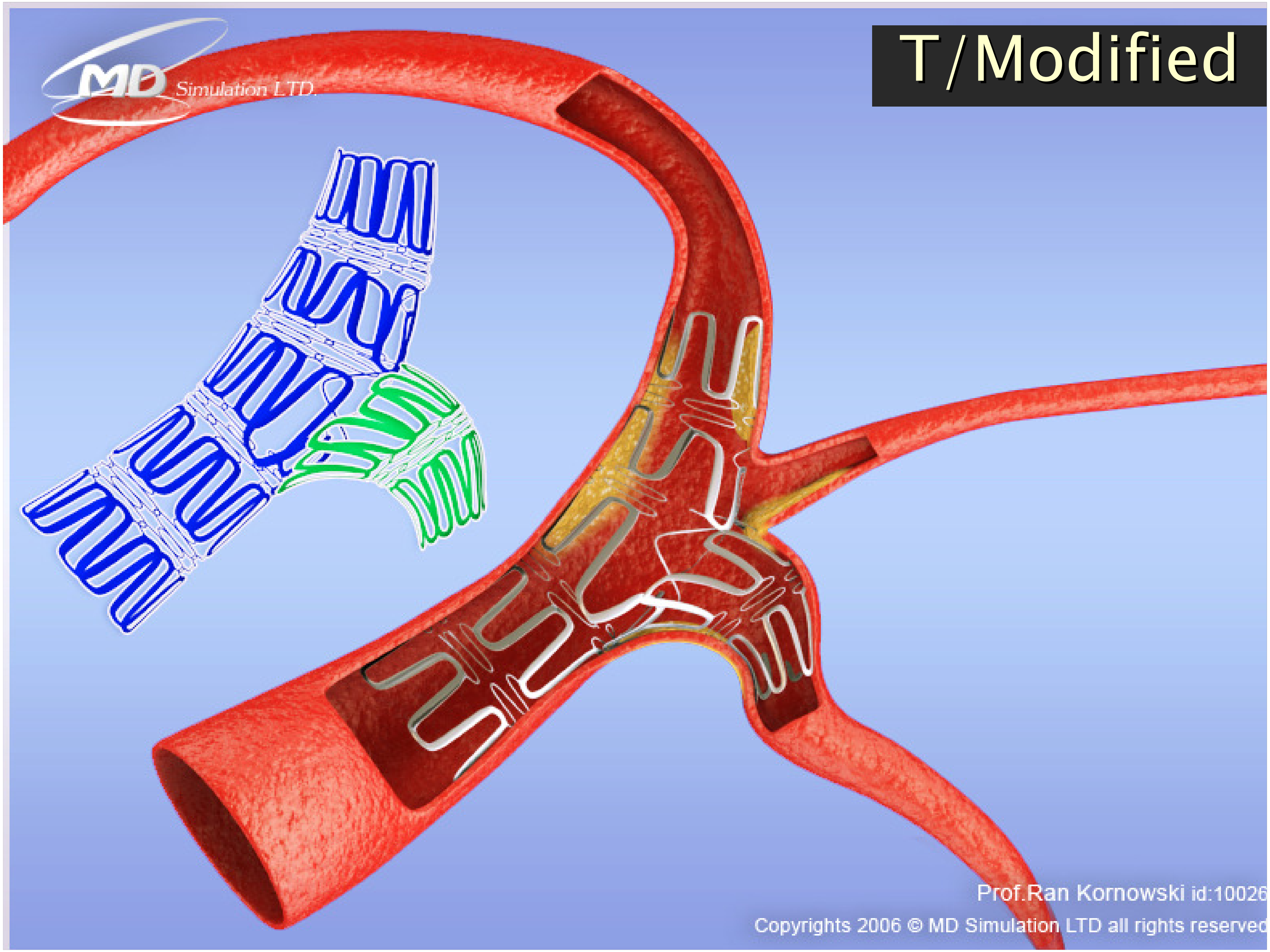
# Diffuse-calcified LM stenosis



# Challenges in distal LM stenting

- Major determinants of procedural success:
  - Vessels diameters (LM and LAD/LCX)
  - Angle between LM to LAD/LCX
  - Presence of an intermediate branch
  - Plaque distribution
  - Plaque composition and amount of calcification
  - Potential for plaque shifting
  - Need for lesion “preparation”

# Provisional


T/Modified
MD Simulation LTD.
Prof.Ran Kornowski id:10026
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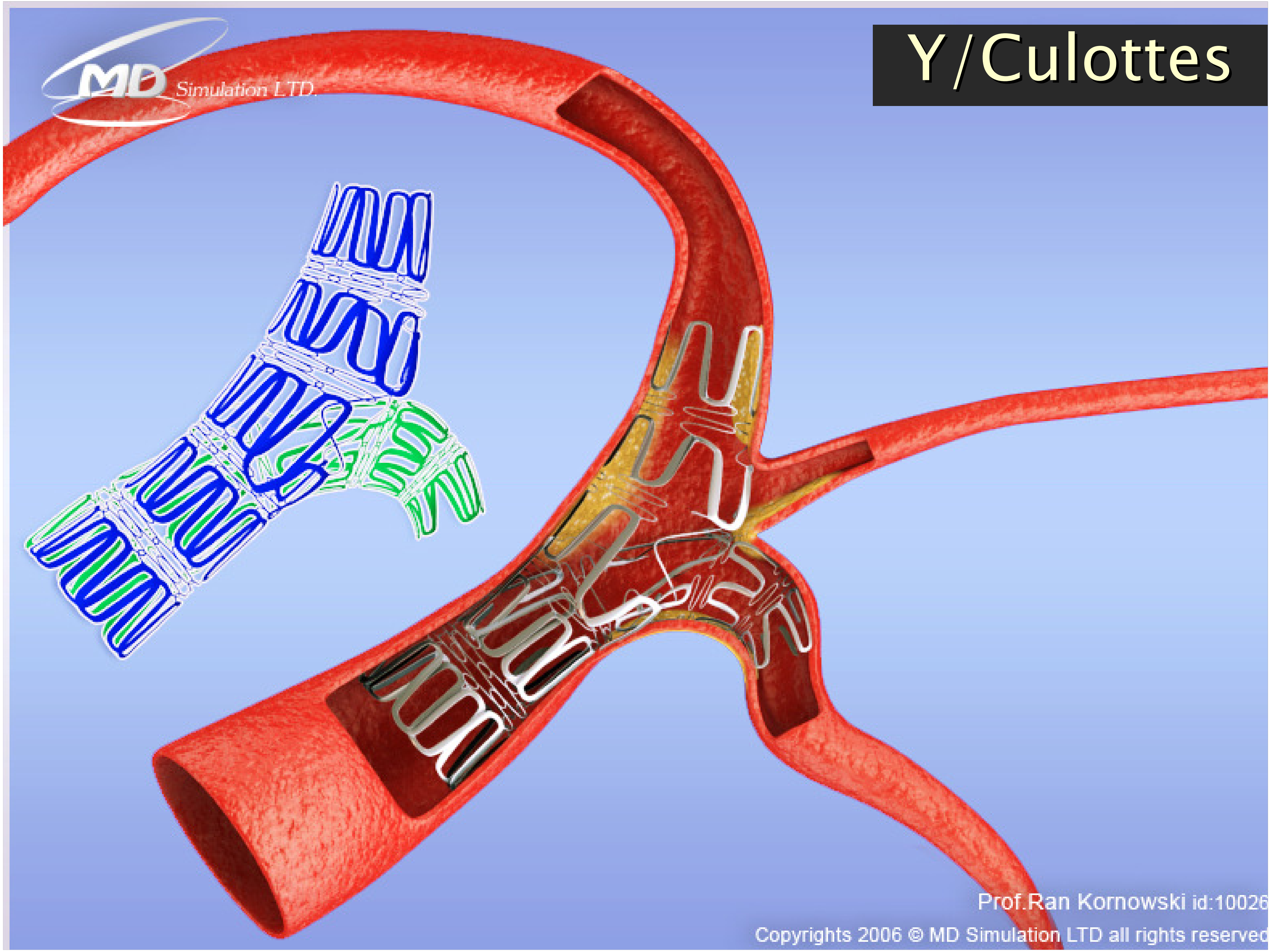
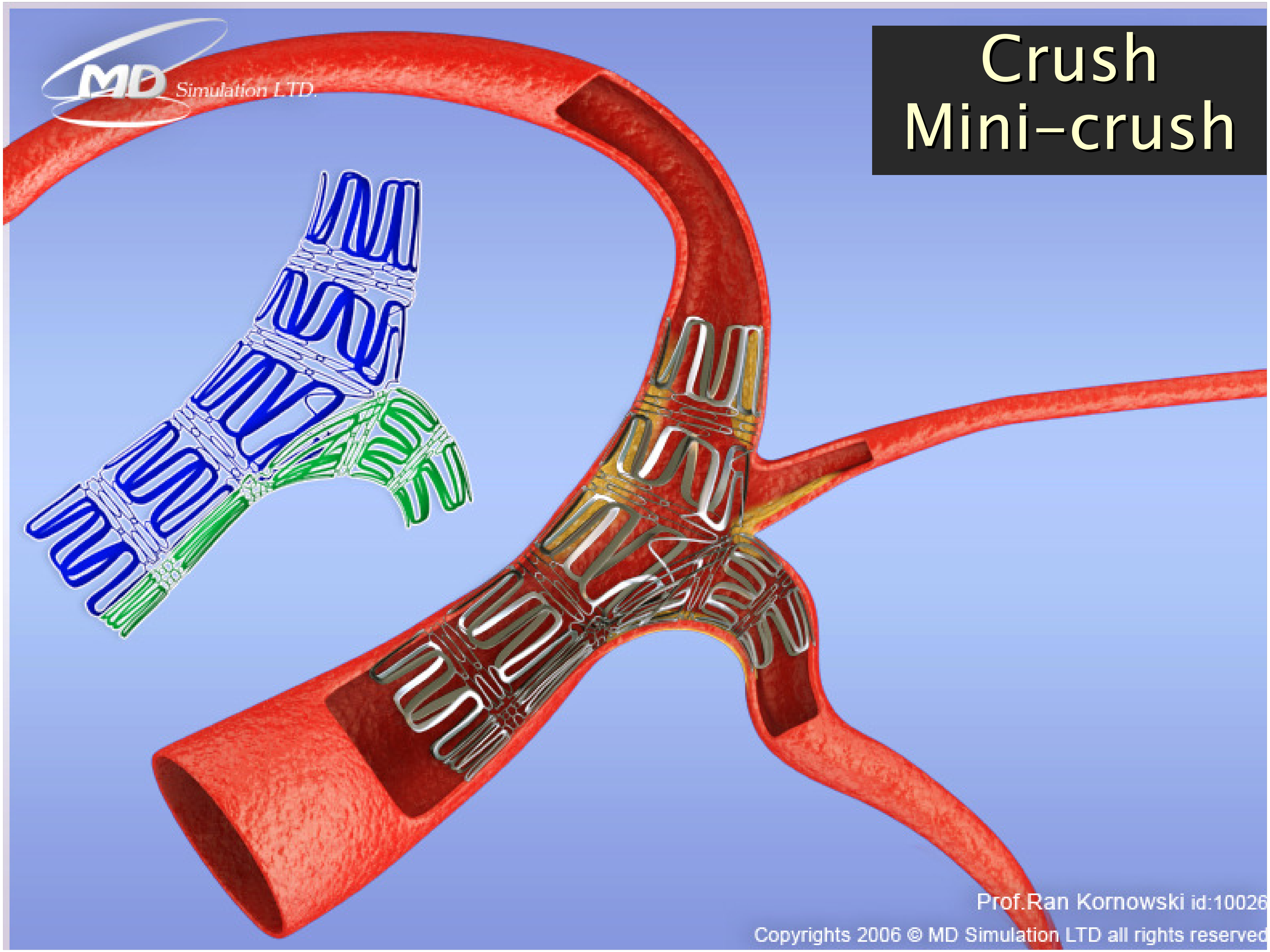
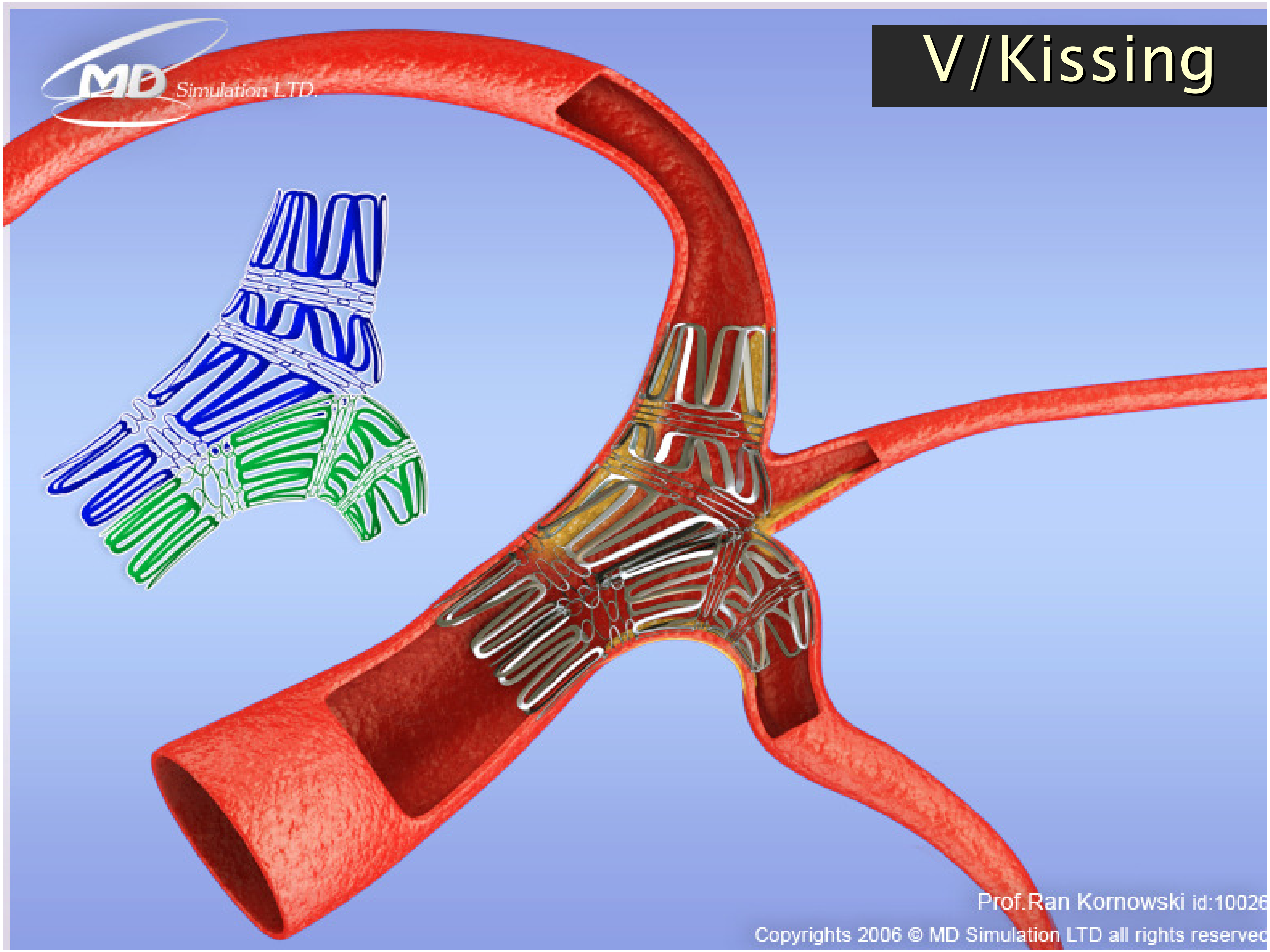
# Y/Culottes




Prof.Ran Kornowski id:10026

# Crush
# Mini-crush

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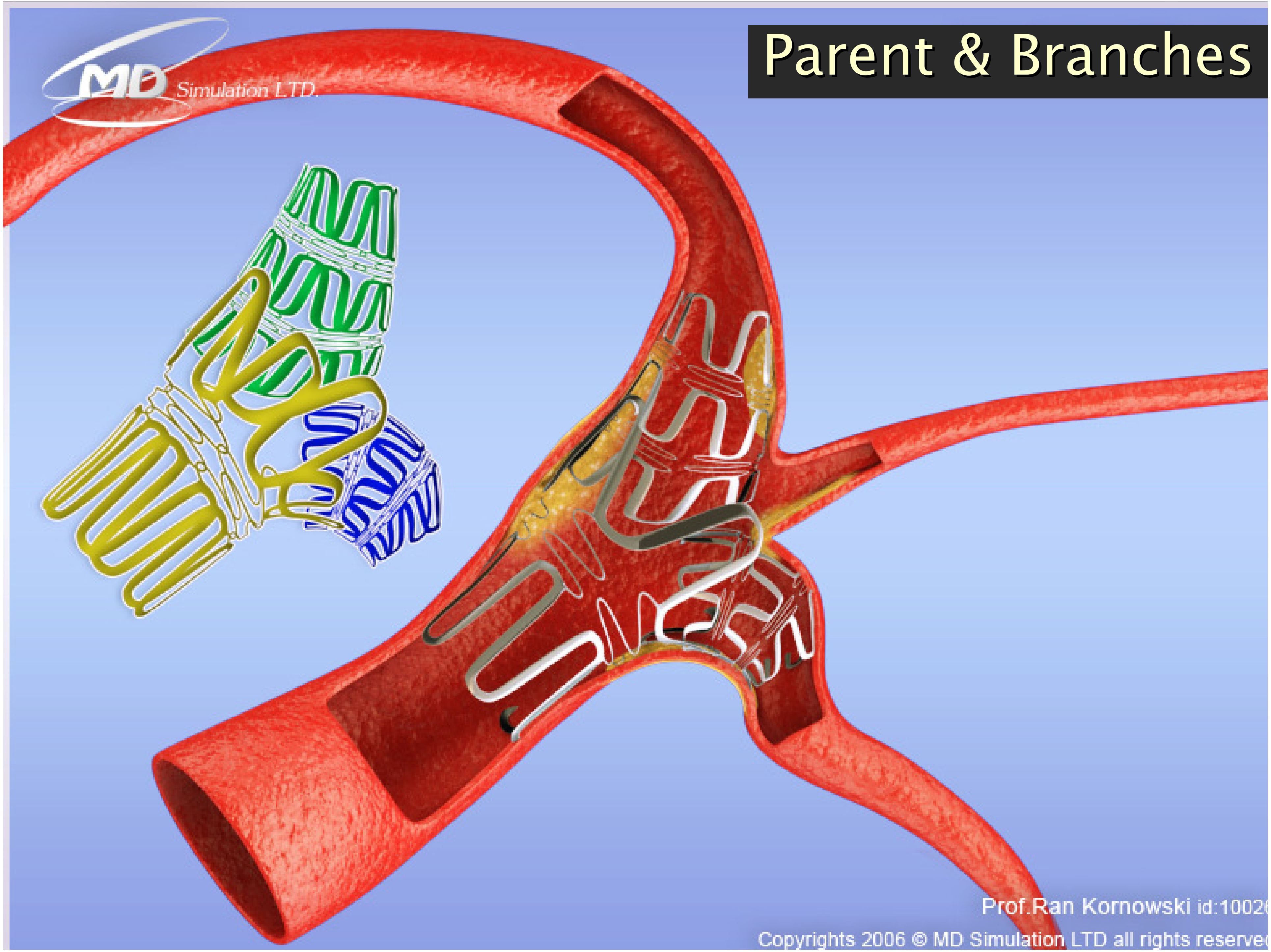
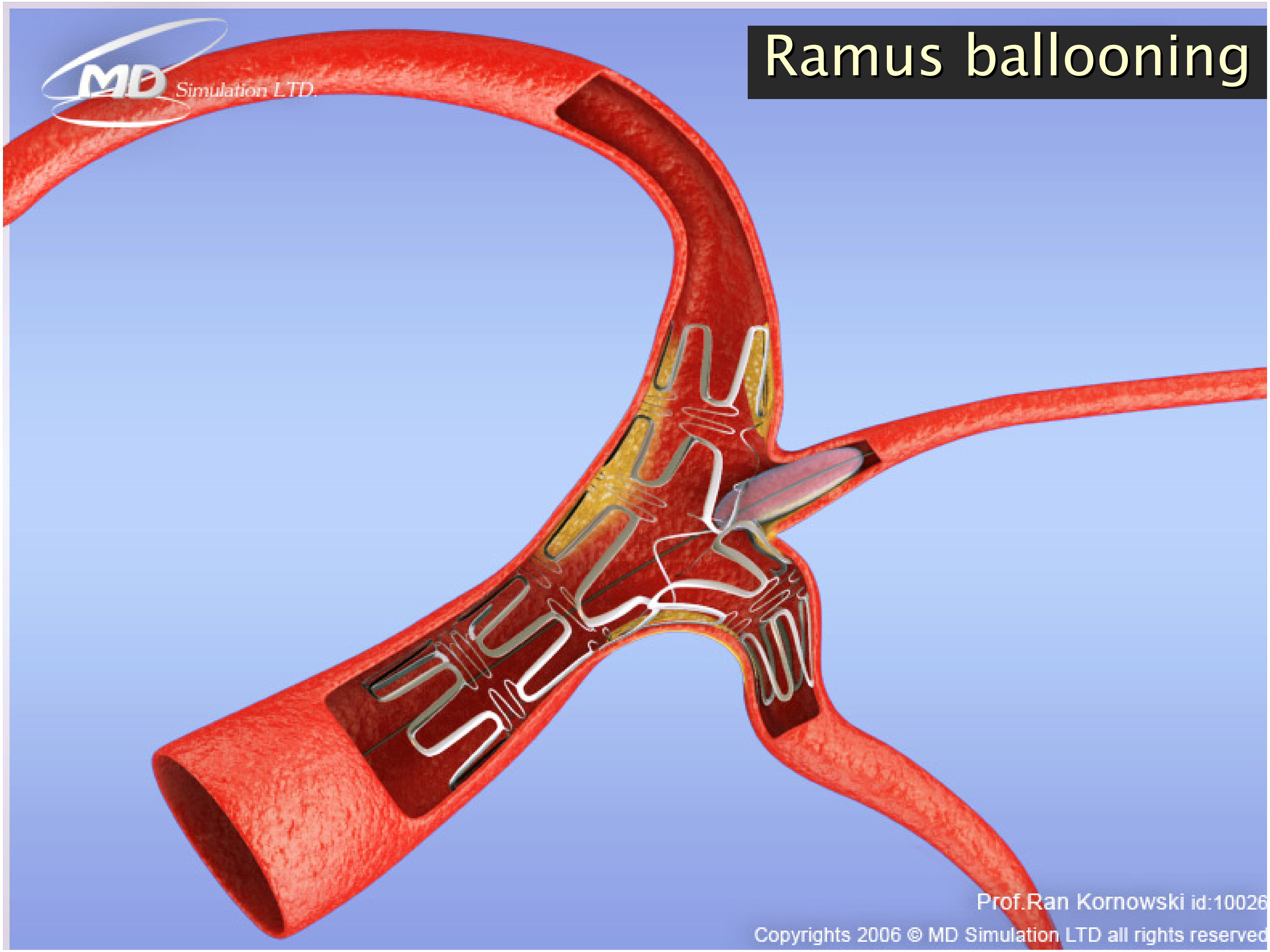
# Parent & Branches

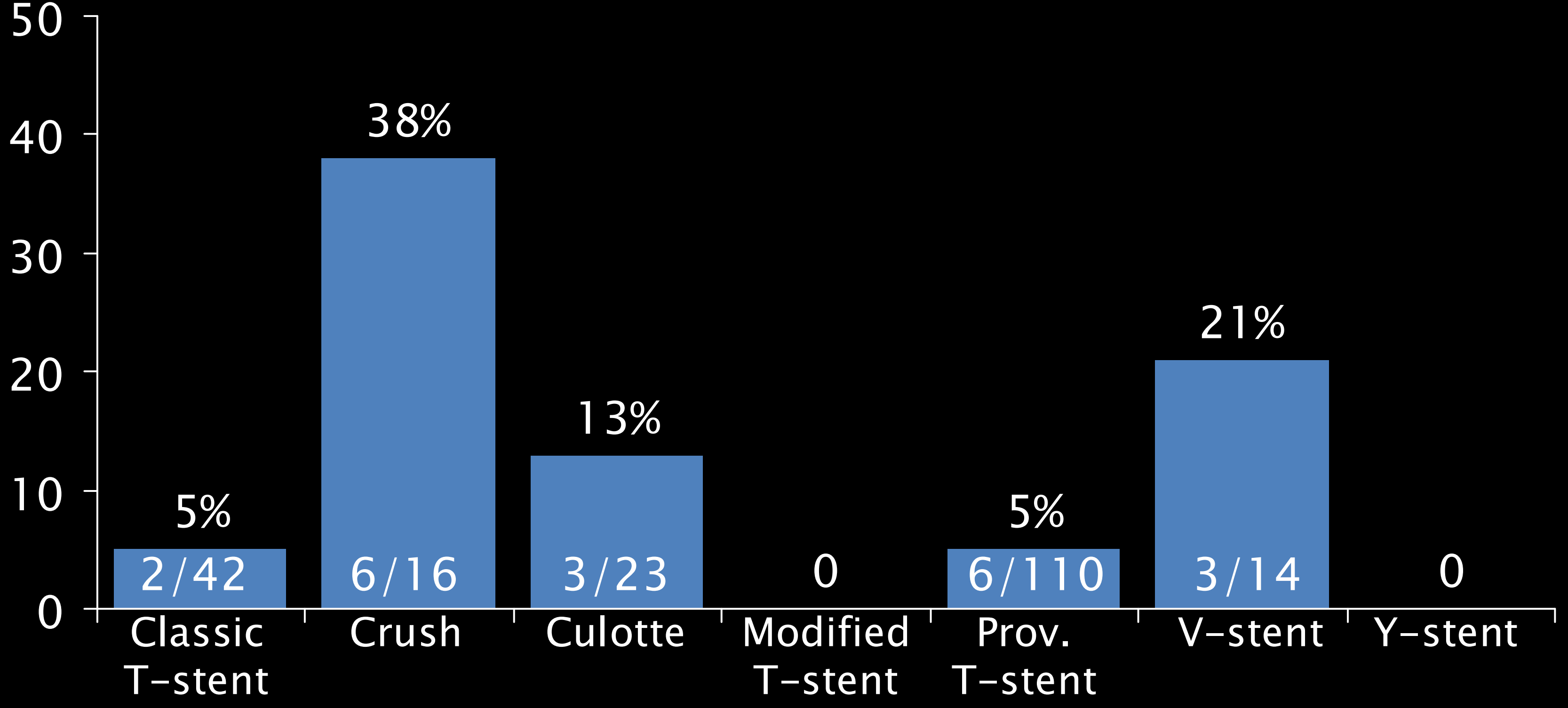


# Ramus ballooning



# Baseline LM Bifurcation Stenting Techniques Requiring Re-treatment

*LM Distal PCI (n=20 lesions)*

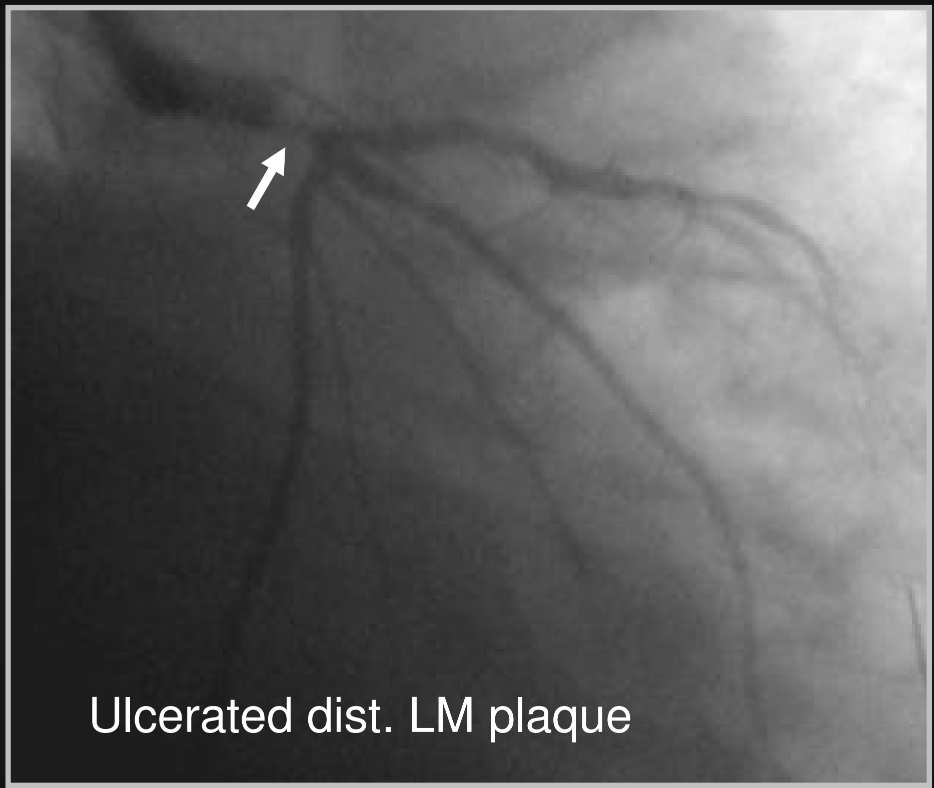



5/20 (25%) lesions originally treated with 1 stent
15/20 (75%) originally treated with 2 or 3 stents

Bar graphs represent percent of baseline treated lesions

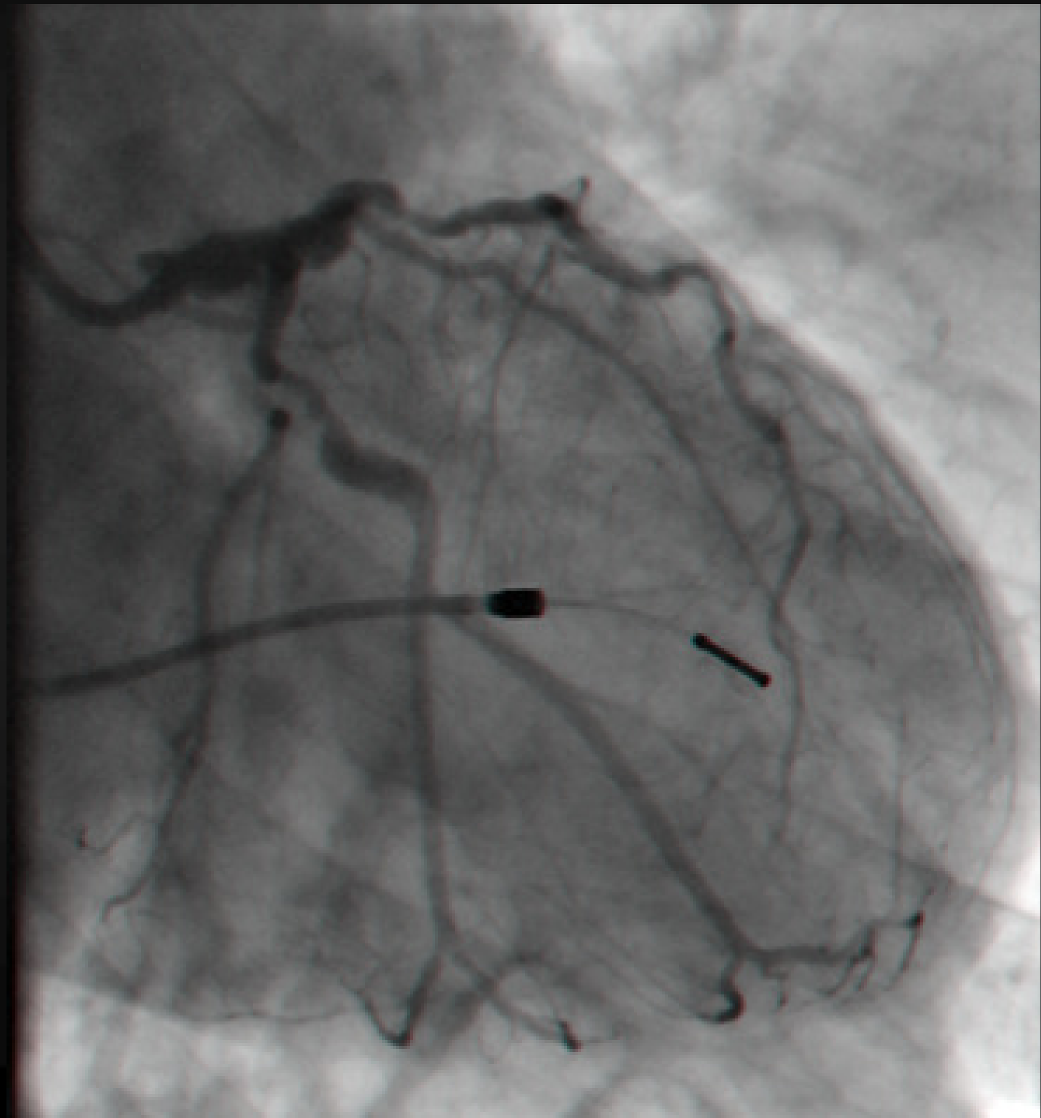
The TAXUS™ Express²™ Stent System is contraindicated for use in patients with unprotected left main coronary artery disease and in vessels involving bifurcation.

# Distal LM stenting during STEMI

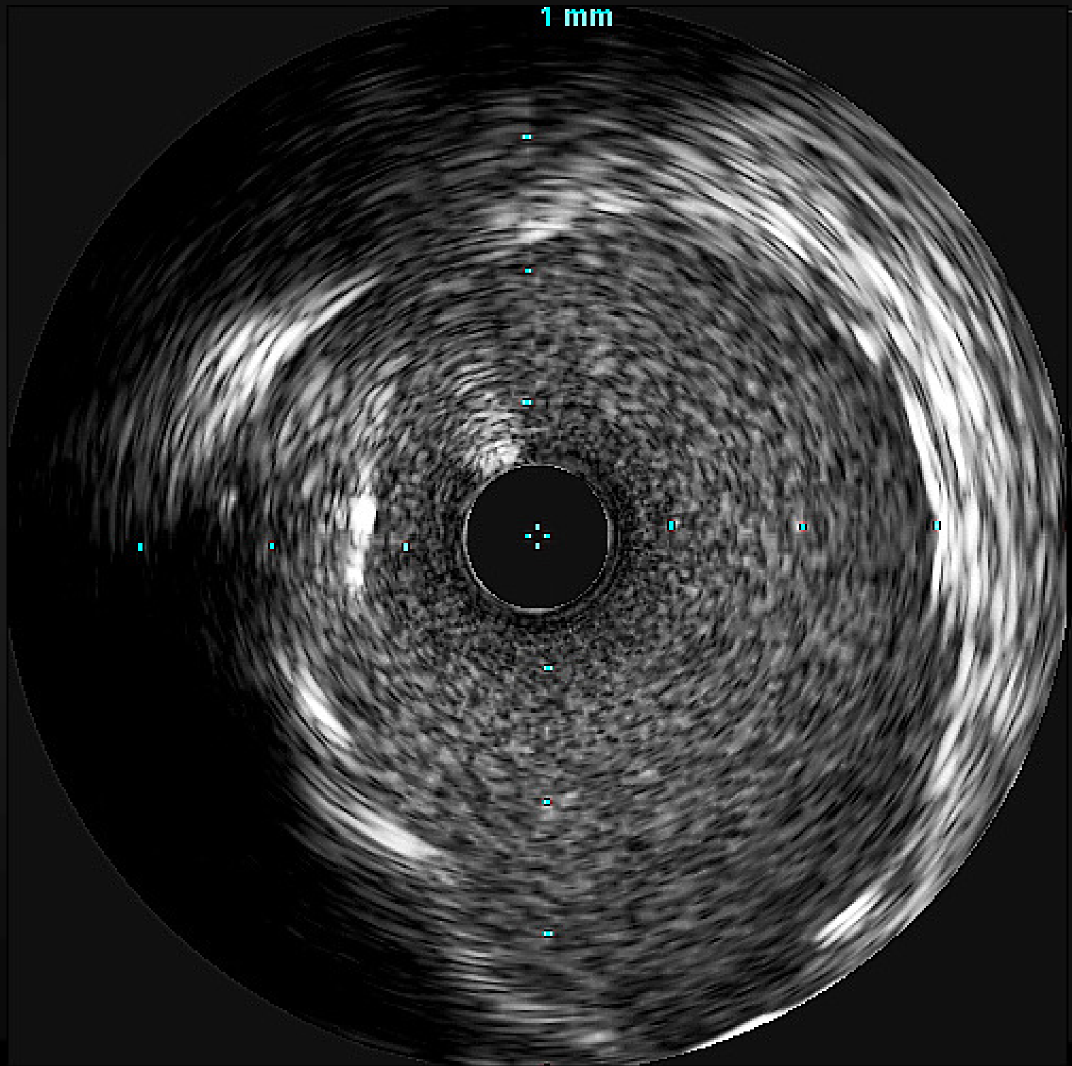



# Distal LM stenting @trifurcation

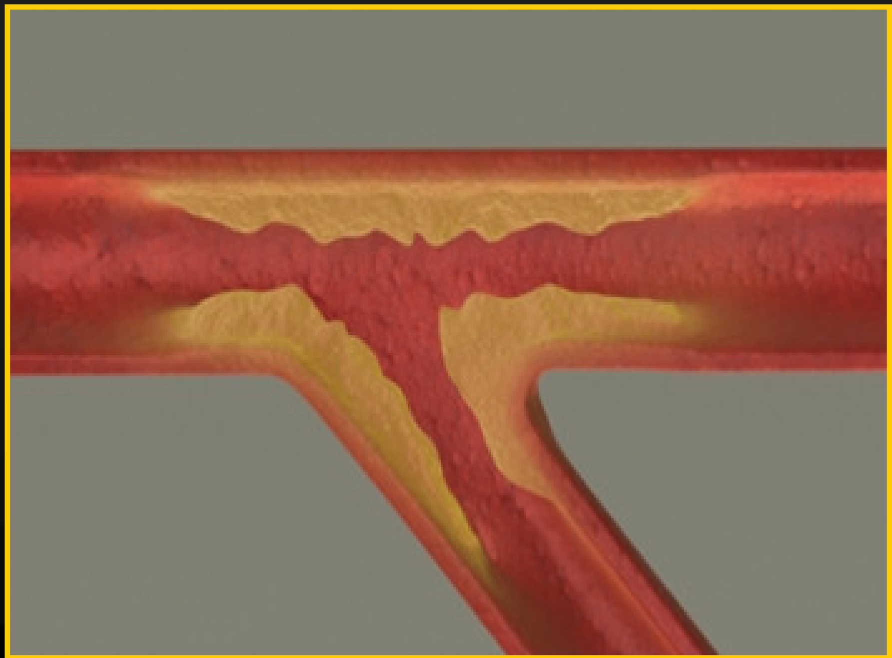

# Distal LM Stenosis



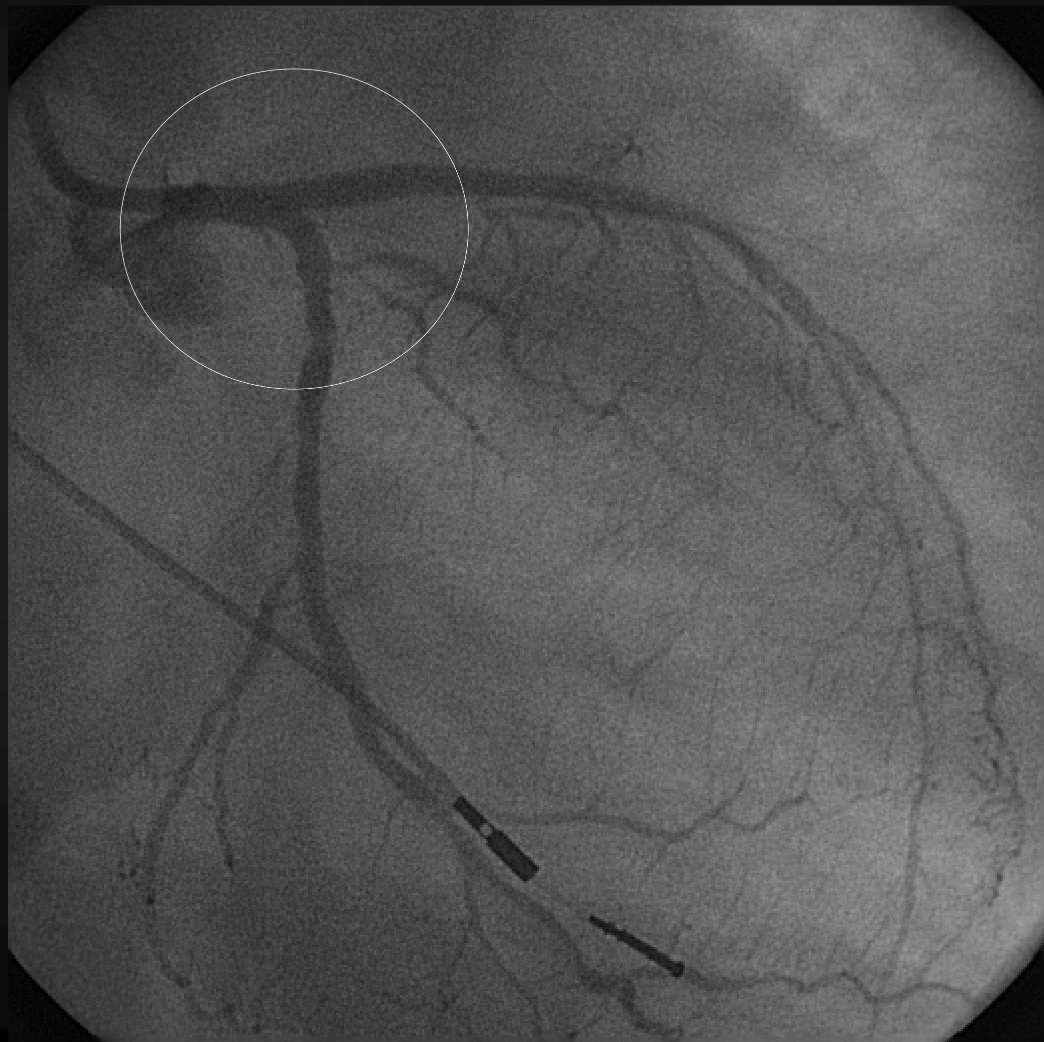
# Complex Distal LM stenting



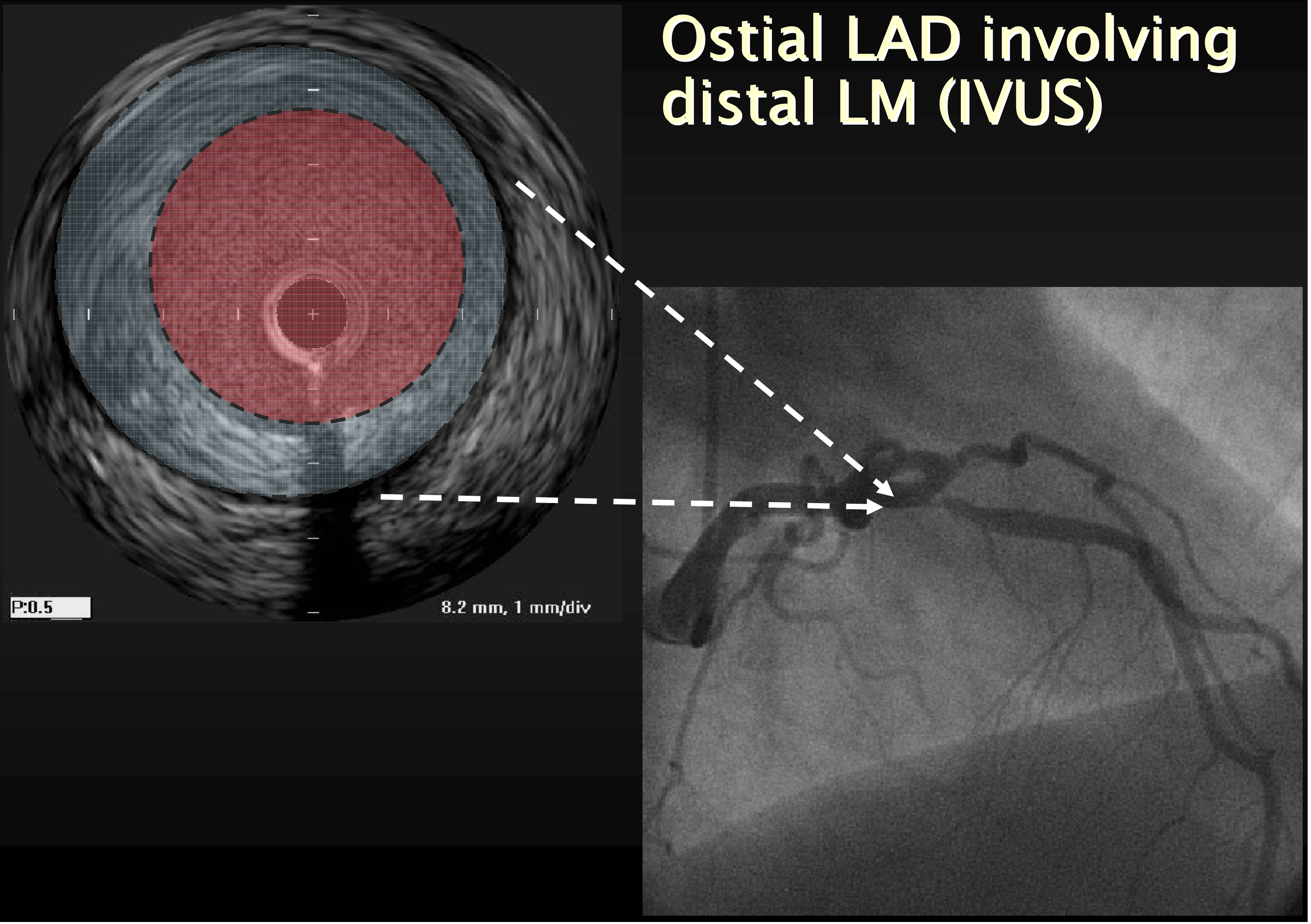
# LM Equivalent disease



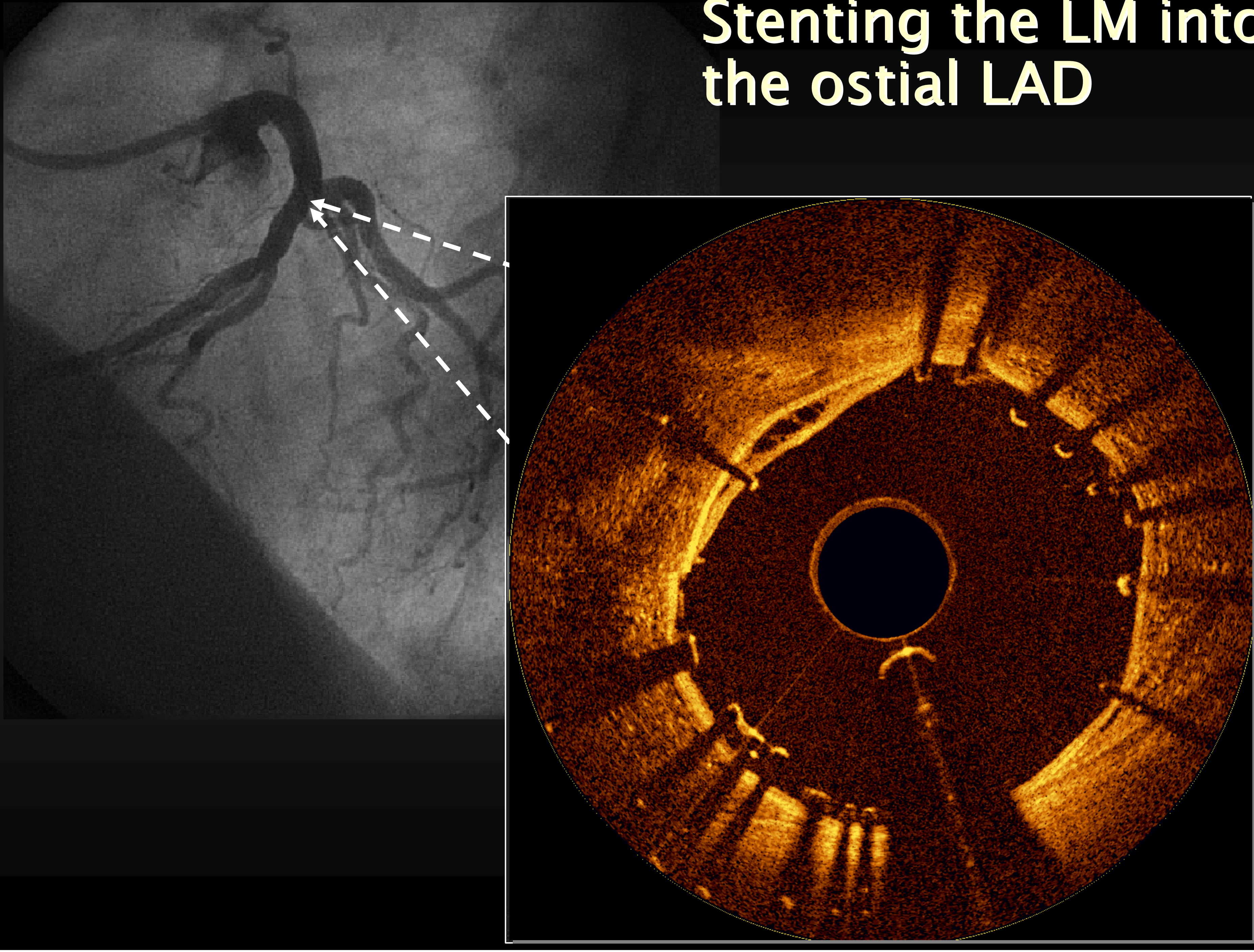
# LM Equivalent disease treated using the 'mini-crush' technique



# Ostial LAD involving distal LM (IVUS)



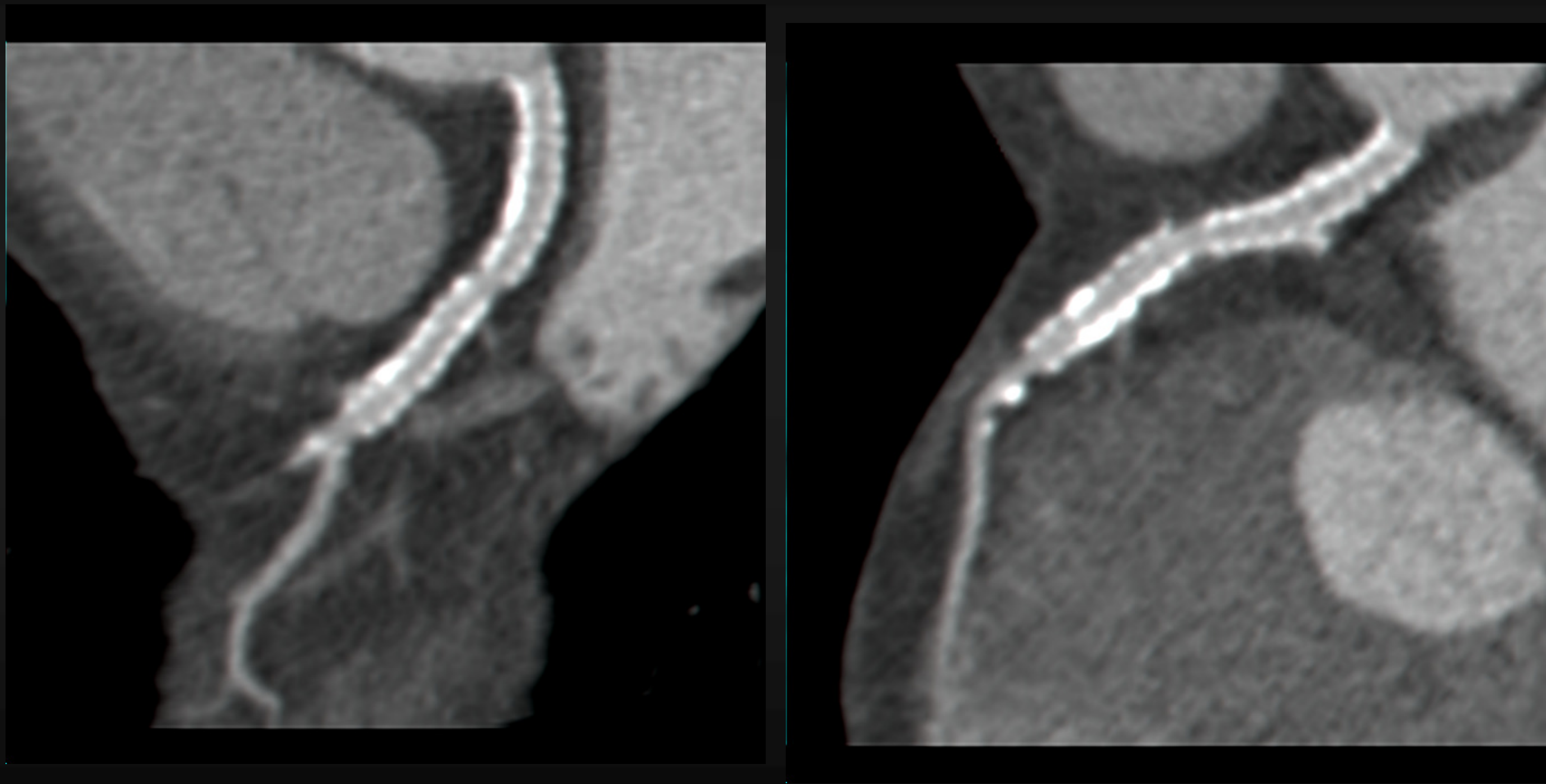
# Stenting the LM into the ostial LAD



# Long-term considerations

- Plavix vs. Prasugrel vs. Ticagrelor and for how long?
- Platelets inhibition tests?
- How to follow?
  - Symptoms driven?
  - Functional tests? SPECT? Stress echo?
  - Repeat angiography? When?
  - Cardiac CTA? When?

# LM stent imaging using Cardiac CTA



The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 APRIL 24, 2008 VOL. 358 NO. 17

# Stents versus Coronary-Artery Bypass Grafting for Left Main Coronary Artery Disease

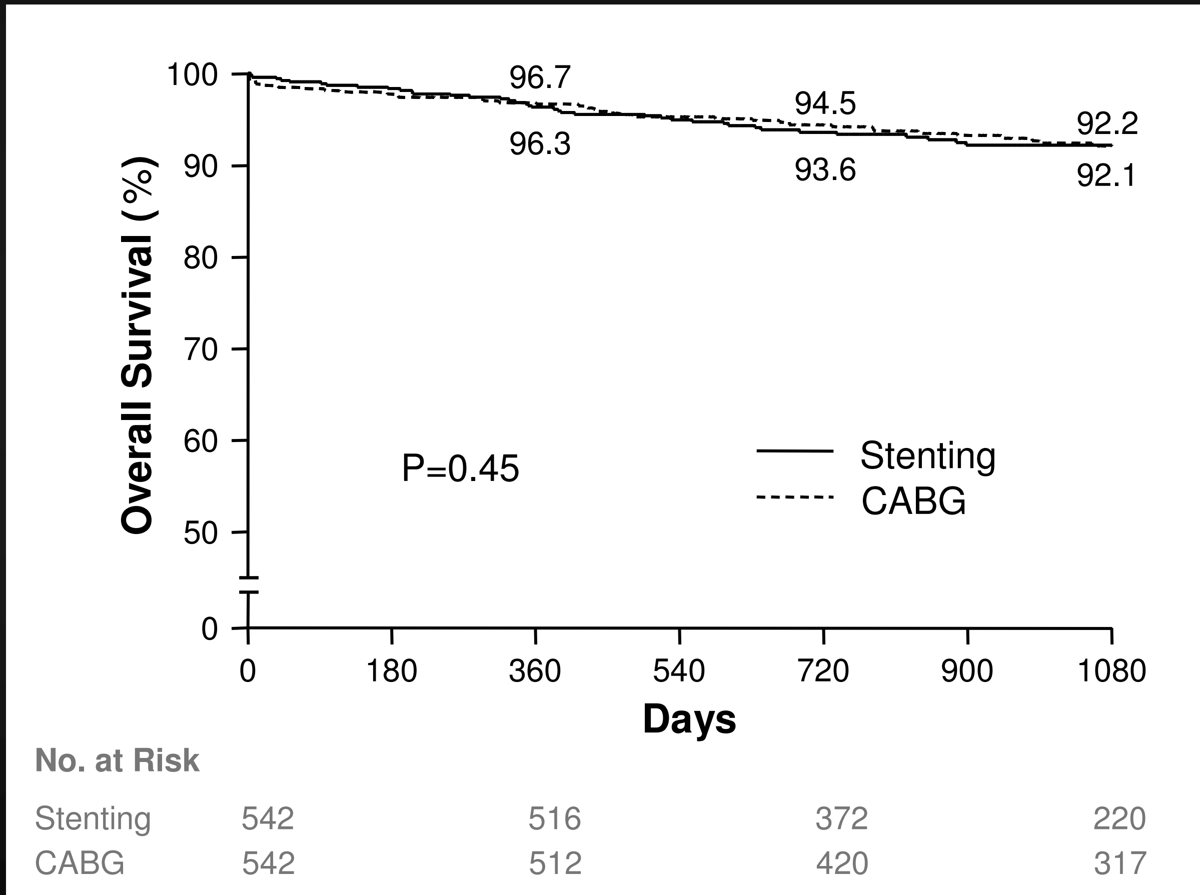
Ki Bae Seung, M.D., Duk-Woo Park, M.D., Young-Hak Kim, M.D., Seung-Whan Lee, M.D., Cheol Whan Lee, M.D., Myeong-Ki Hong, M.D., Seong-Wook Park, M.D., Sung-Cheol Yun, Ph.D., Hyeon-Cheol Gwon, M.D., Myung-Ho Jeong, M.D., Yangsoo Jang, M.D., Hyo-Soo Kim, M.D., Pum Joon Kim, M.D., In-Whan Seong, M.D., Hun Sik Park, M.D., Taehoon Ahn, M.D., In-Ho Chae, M.D., Seung-Jea Tahk, M.D., Wook-Sung Chung, M.D., and Seung-Jung Park, M.D.

"In a cohort of patients with unprotected LMCA disease, we found no significant differences in rates of death or of the composite endpoint of death, Q-wave MI or stroke between patients receiving stents and those undergoing CABG. However, stenting even with DES was associated with higher rates of TVR that was CABG."

Seung et al, NEJM 2008

# MAIN Compare: Mortality

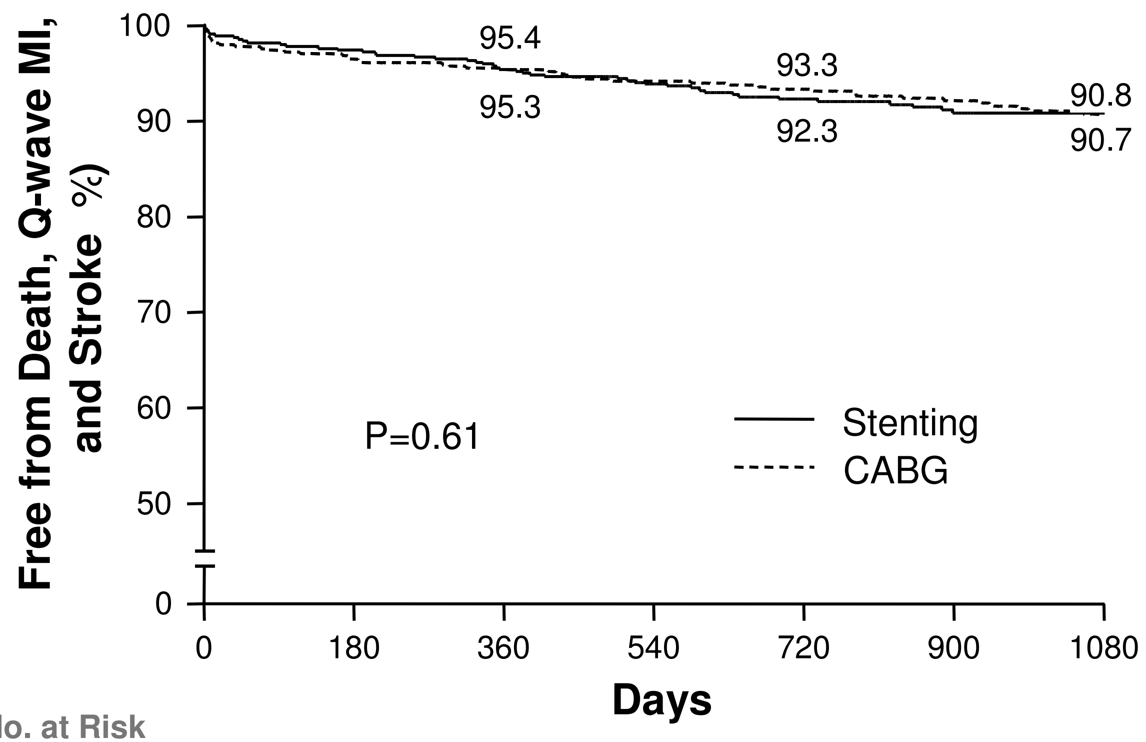
**(Overall PCI and CABG matched cohort: 542 pairs)**




Seung et al, NEJM 2008

# MAIN Compare: Death, Q-MI, or Stroke

**(Overall PCI and CABG matched cohort: 542 pairs)**



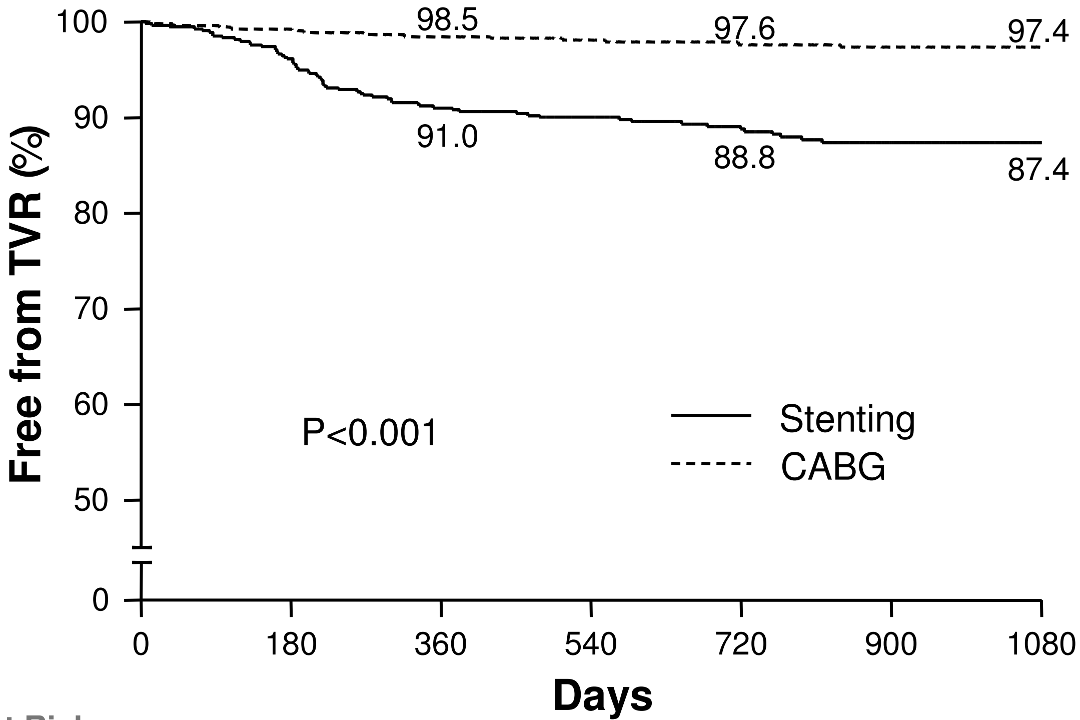

**No. at Risk**

| | 0 | 360 | 720 | 1080 |
|---|---|---|---|---|
| Stenting | 542 | 510 | 366 | 218 |
| CABG | 542 | 502 | 412 | 309 |

Seung et al, NEJM 2008

# MAIN Compare: Target-vessel Revasc.

**(Overall PCI and CABG matched cohort: 542 pairs)**

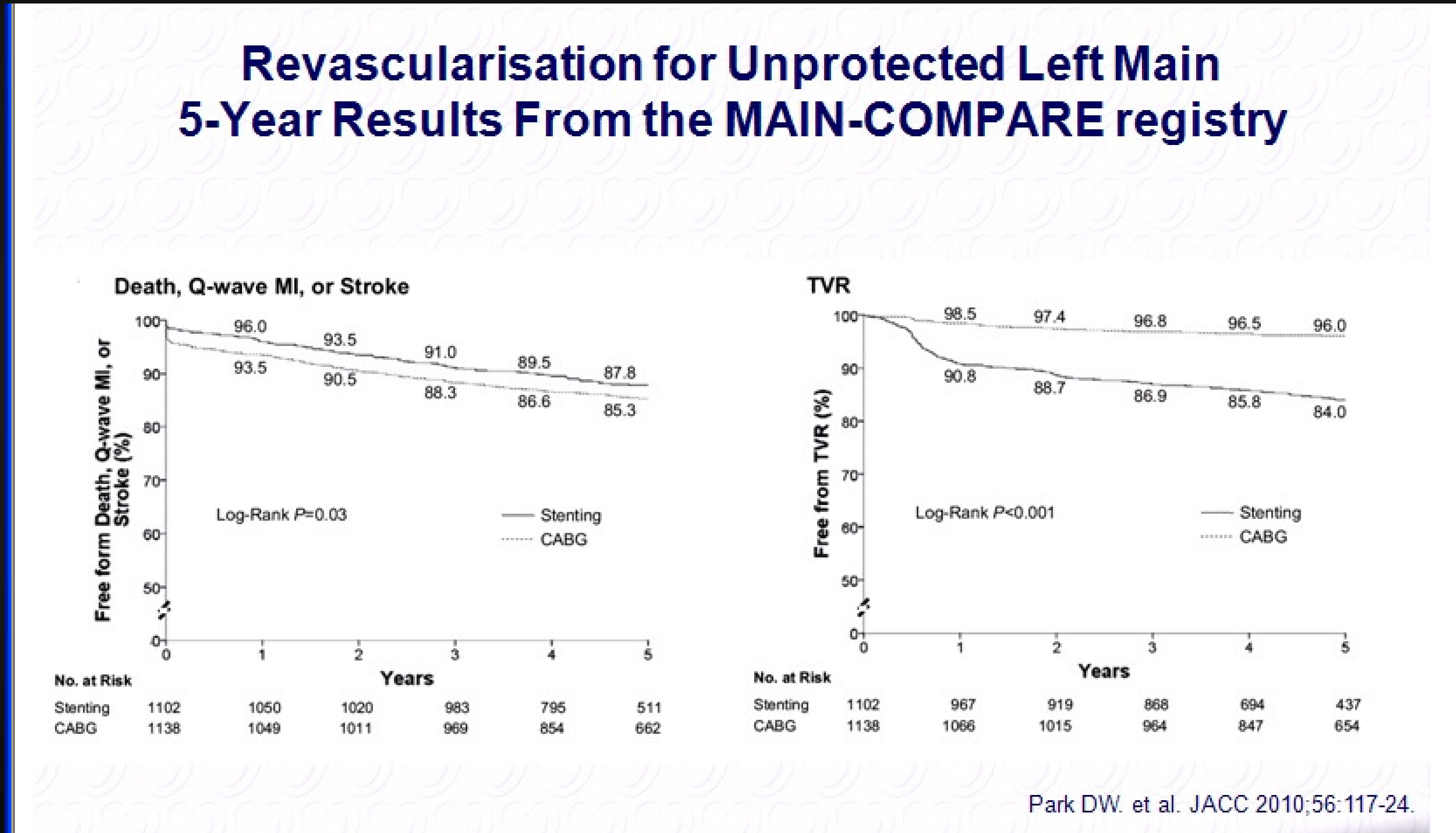



**No. at Risk**

| | | | | |
|---|---|---|---|---|
| Stenting | 542 | 471 | 331 | 193 |
| CABG | 542 | 503 | 408 | 305 |

Seung et al, NEJM 2008

# MAIN Compare: 5 Years Results



IMAJ • VOL 11 • MARCH 2009

# Clinical Results of Unprotected Left Main Coronary Stenting

Itsik Ben-Dor MD, Hana Vaknin-Assa MD, Eli Lev MD, David Brosh MD, Shmuel Fuchs MD, Abid Assali MD and Ran Kornowski MD

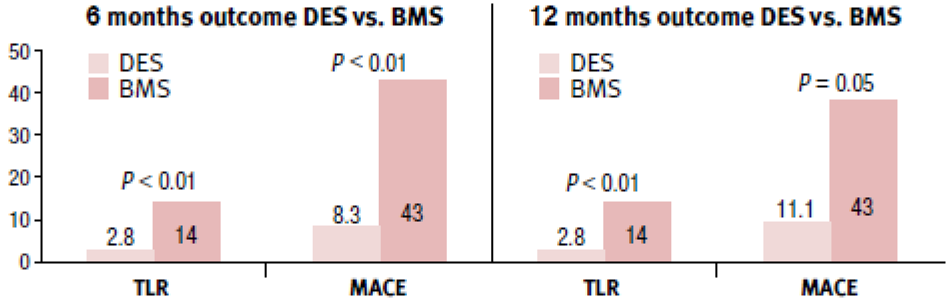
Cardiac Catheterization Laboratories, Department of Cardiology, Rabin Medical Center (Beilinson Campus), Petah Tikva, and Sackler Faculty of Medicine, Tel Aviv University, Ramat Aviv, Israel

**Table 3.** Clinical outcome at 1 and 6 months after PCI

| | 1 month | 6 months | 12 months |
|---|---|---|---|
| Death (overall) | 8 (11.3%) | 13 (18.3%) | 14 (19.7%) |
| Death (planned procedure) | 1 (2.3%) | 2 (4.6%) | 3 (6.9%) |
| Death (emergent procedure) | 7 (25%) | 11 (39%) | 11 (39%) |
| Re-myocardial infarction | 0% | 5 (7%) | 5 (7%) |
| TVR | 1 (1.4%) | 6 (8.5%) | 6 (8.5%) |
| CABG | 1 (1.4%) | 4 (5.6%) | 4 (5.6%) |
| Stent thrombosis | 0 | 0 | 0 |
| MACE (overall) | 9 (12.7%) | 18 (25.3%) | 19 (26.8%) |
| MACE (planned procedure) | 2 (4.6%) | 6 (14%) | 7 (16.3%) |
| MACE (emergent procedure) | 7 (25%) | 12 (43%) | 12 (43%) |

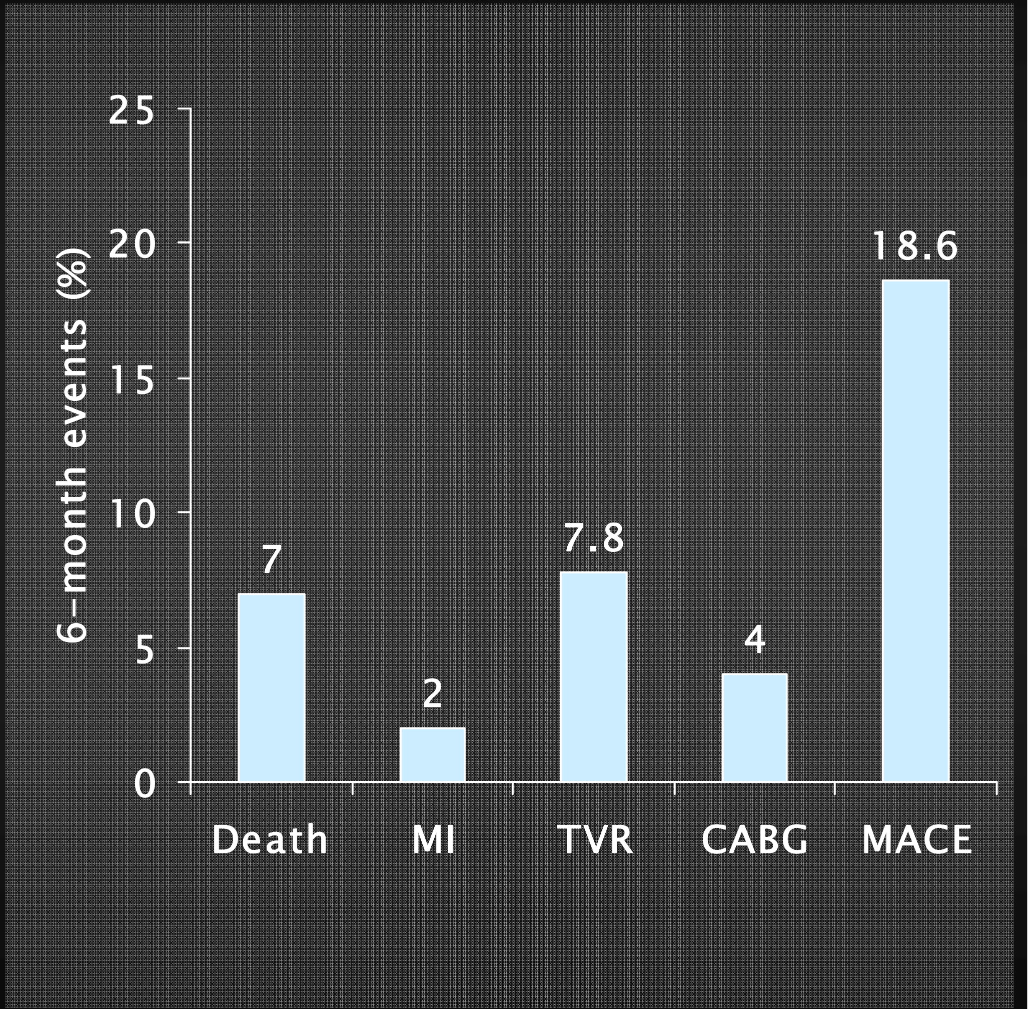
TVR = target vessel revascularization, CABG = coronary artery bypass grafting, MACE = major adverse cardiac events.

**Figure 1.** Outcomes at 1, 6 and 12 months for PCI with DES vs. BMS



# Unprotected LM PCI results @RMC

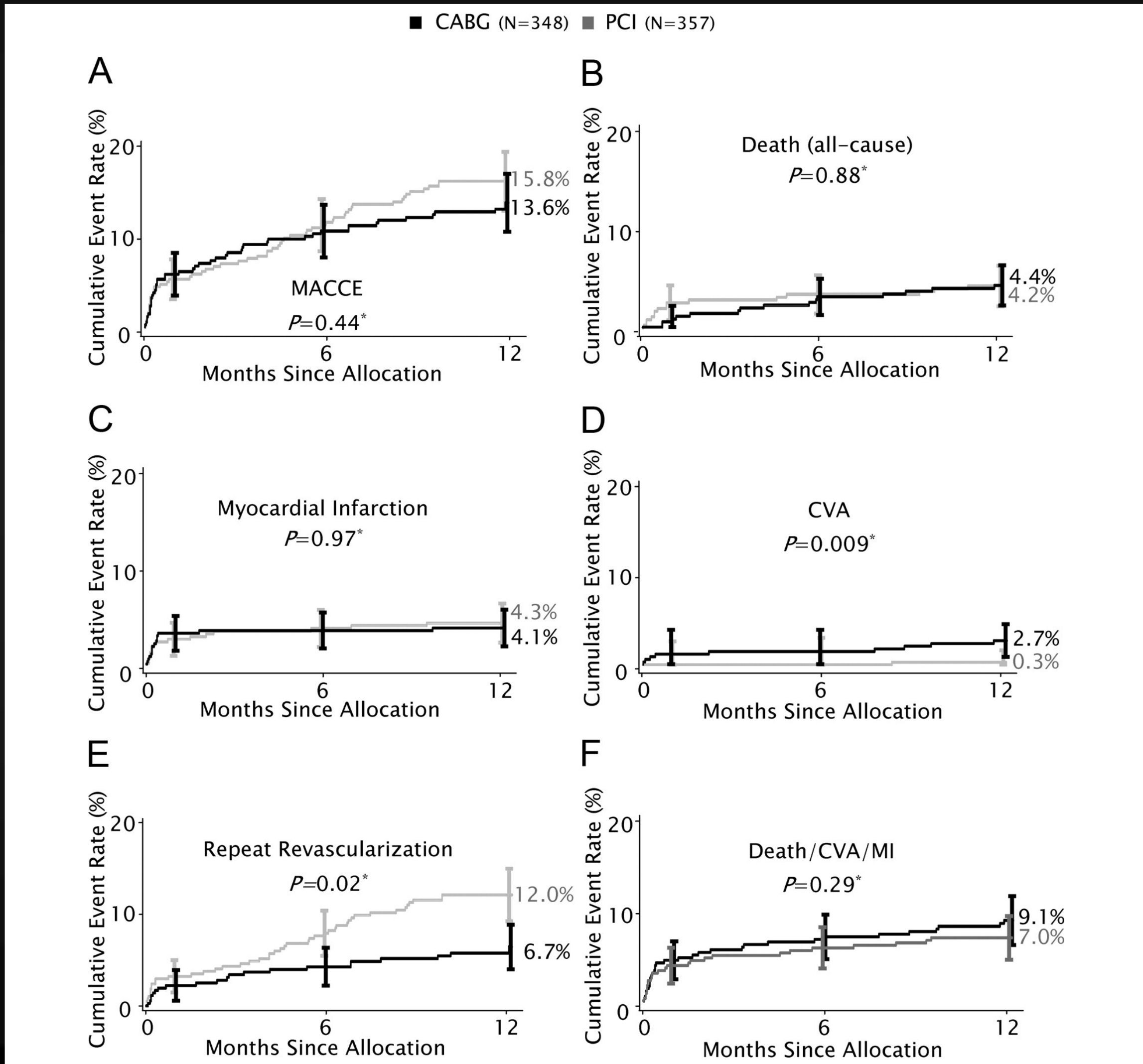
- 102 pts with UPLM stenting @RMC between 2006-2009
  - age 74±12 yrs
  - 64% male
  - 34% diabetics
  - 72% ACS
  - 45% distal LM disease
  - EuroScore=7.2%
  - 65% rate of DES use
  - 100% angio success




Assali A, Kornowski R et al. Israeli Heart Meeting 4.2010

# SYNTAX Trial: PCI vs. CABG results

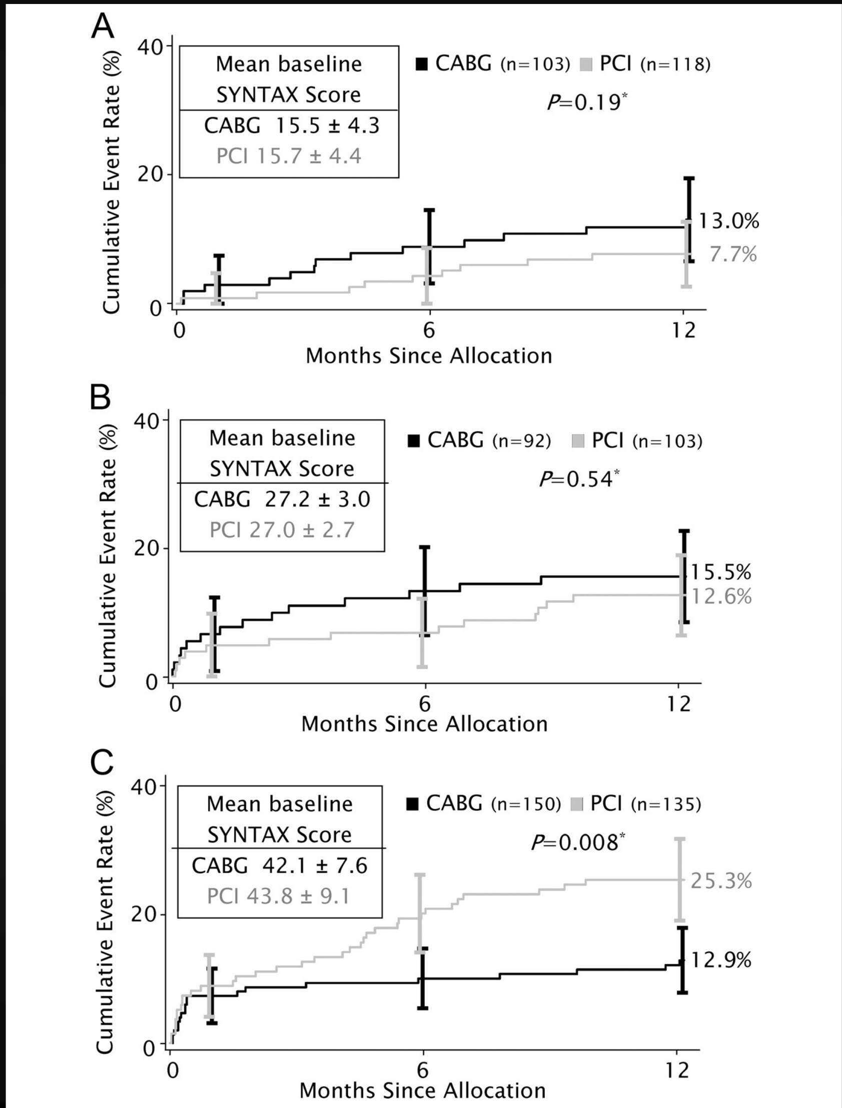
**Kaplan-Meier estimates of A, total MACCE; B, all-cause death; C, MI; D, CVA; E, repeat revascularization; and F, death/CVA/MI for PCI versus CABG in patients with LM disease.**




Morice M et al. Circulation 2010;121:2645-2653

# SYNTAX Trial: PCI vs. CABG results

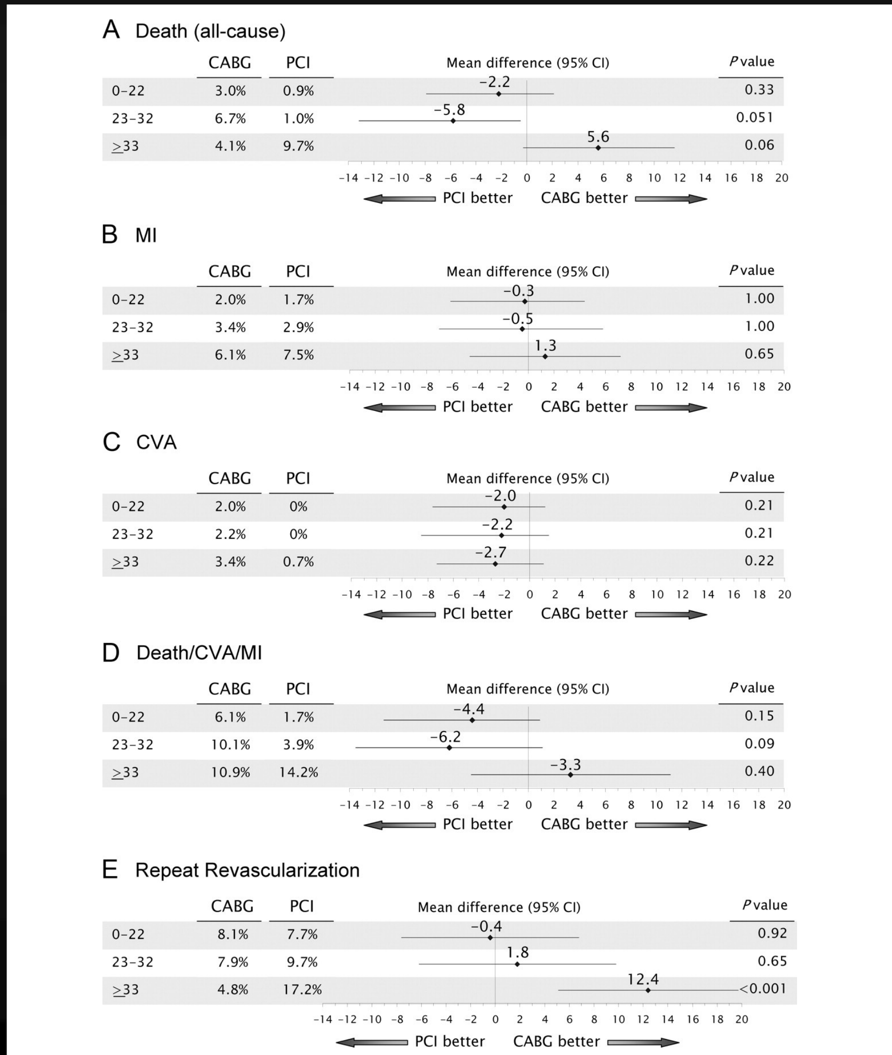
**Kaplan-Meier estimates of 1-year MACCE by baseline SYNTAX score tercile.**




**Morice M et al. Circulation 2010;121:2645-2653**

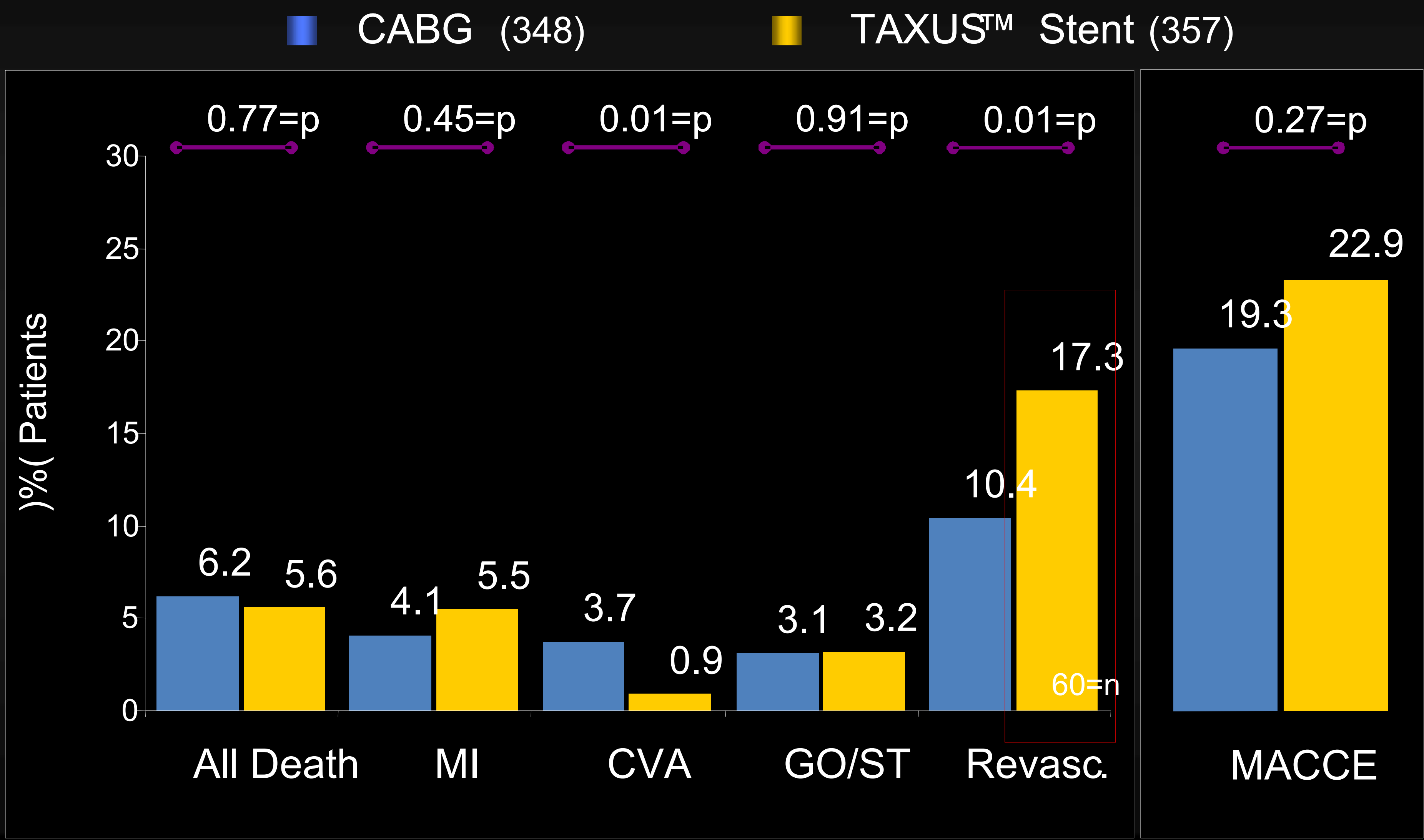
# SYNTAX Trial: PCI vs. CABG results

**One-year incidence of A, all-cause death; B, MI; C, CVA; D, death/CVA/MI; and E, repeat revascularizations in patients with low (0 to 22), intermediate (23 to 32), or high (≥33) baseline unadjusted SYNTAX score.**




**Morice M et al. Circulation 2010;121:2645-2653**

# SYNTAX Trial: **2 Yrs MACCE (LM cohort)**



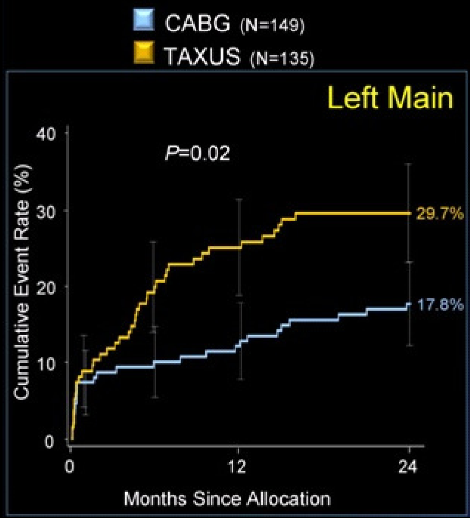

log ;Time to event analysis - rank*P* value

graft occlusion=GO ;stent thrombosis=ST

# SYNTAX Trial: 2 Yrs MACCE
## LM cohort per Syntax Score

### MACCE to 2 Years by SYNTAX Score Tercile *Left Main SYNTAX Score ≥33*

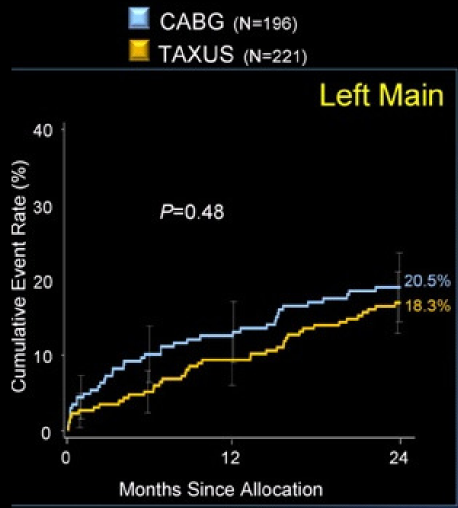
SYNTAX




| | CABG | PCI | *P*-value |
|---|---|---|---|
| Death | 4.1% | 10.4% | 0.04 |
| CVA | 4.2% | 0.8% | 0.08 |
| MI | 6.1% | 8.4% | 0.48 |
| Death, CVA or MI | 11.5% | 15.6% | 0.32 |
| Revasc. | 9.2% | 21.8% | 0.003 |

### MACCE to 2 Years by SYNTAX Score Tercile *Left Main SYNTAX Scores 0-32*

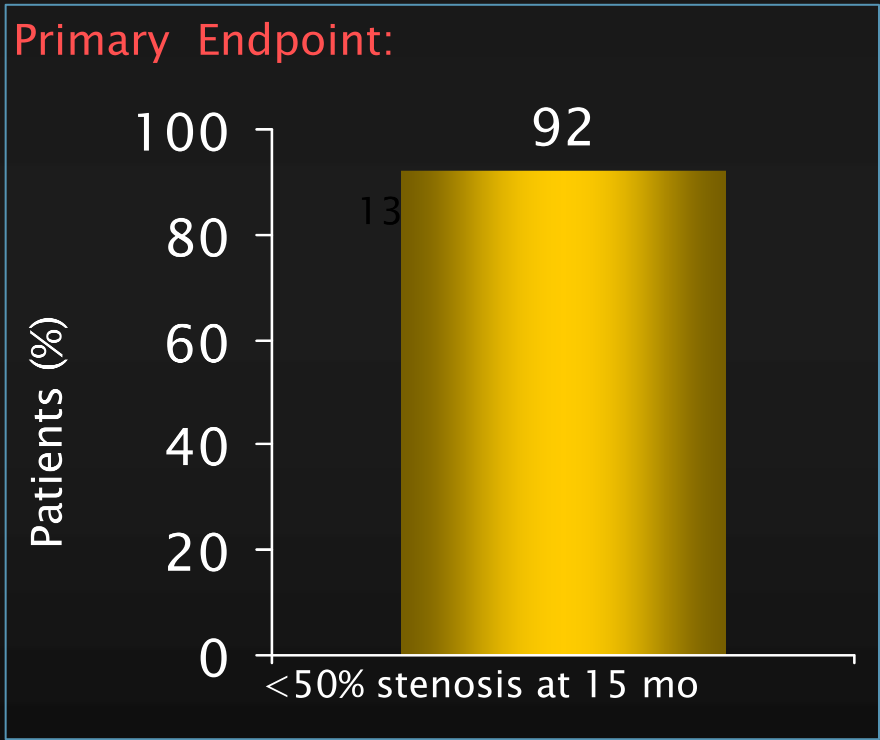
SYNTAX

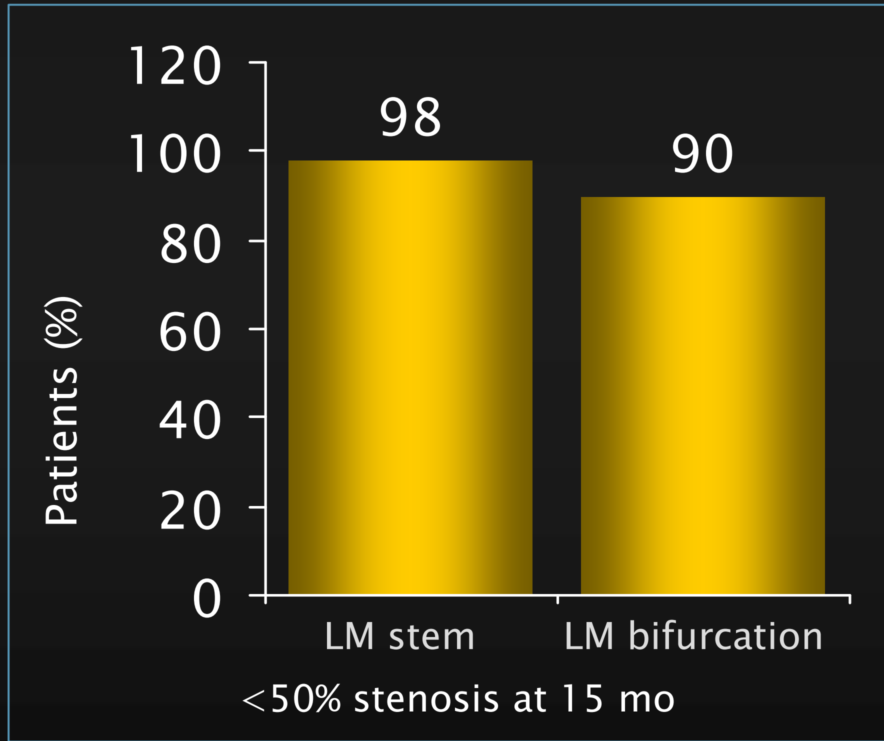



| | CABG | PCI | *P*-value |
|---|---|---|---|
| Death | 7.9% | 2.7% | 0.02 |
| CVA | 3.3% | 0.9% | 0.09 |
| MI | 2.6% | 3.8% | 0.59 |
| Death, CVA or MI | 12.1% | 6.9% | 0.06 |
| Revasc. | 11.4% | 14.3% | 0.44 |

# SYNTAX Le Mans: **TAXUS results**

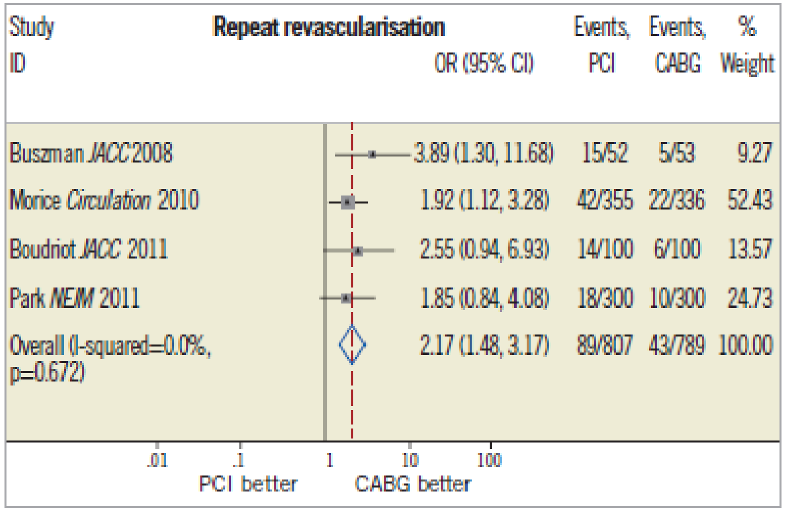
- Angiography for 271 SYNTAX LE MANS pts at 15±1 mos
- Primary Endpoints: Rate of long-term patency of treated LMD by QCA

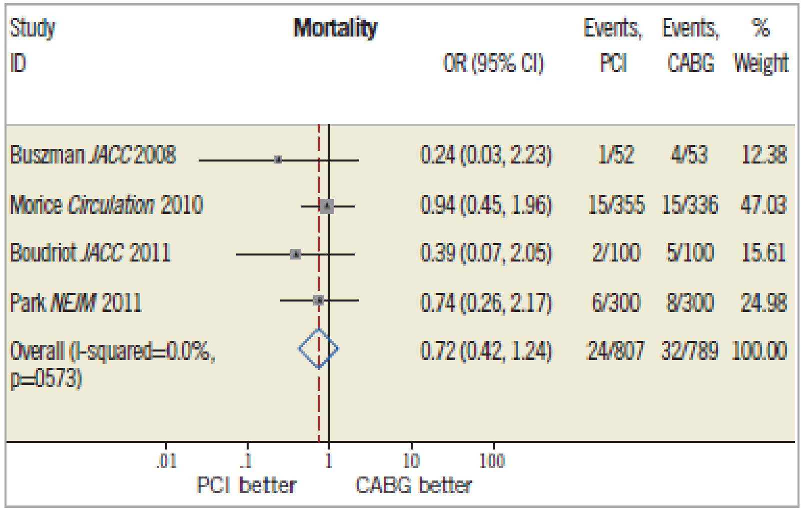


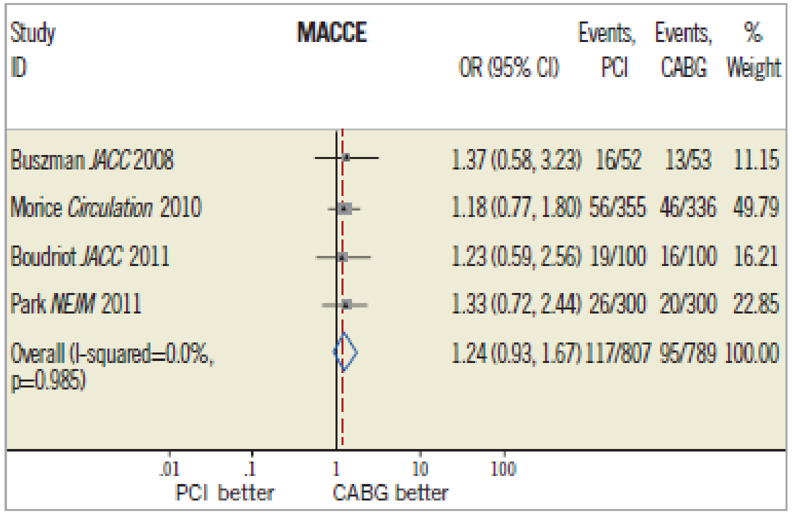



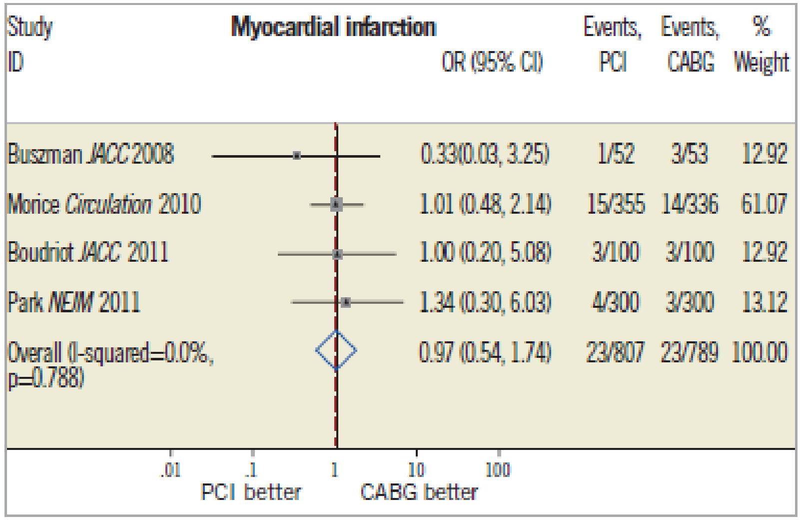

Morice MC et al, EuroIntervention 11.2011

# LM PCI vs. CABG: **Meta-Analysis (N=1611)**



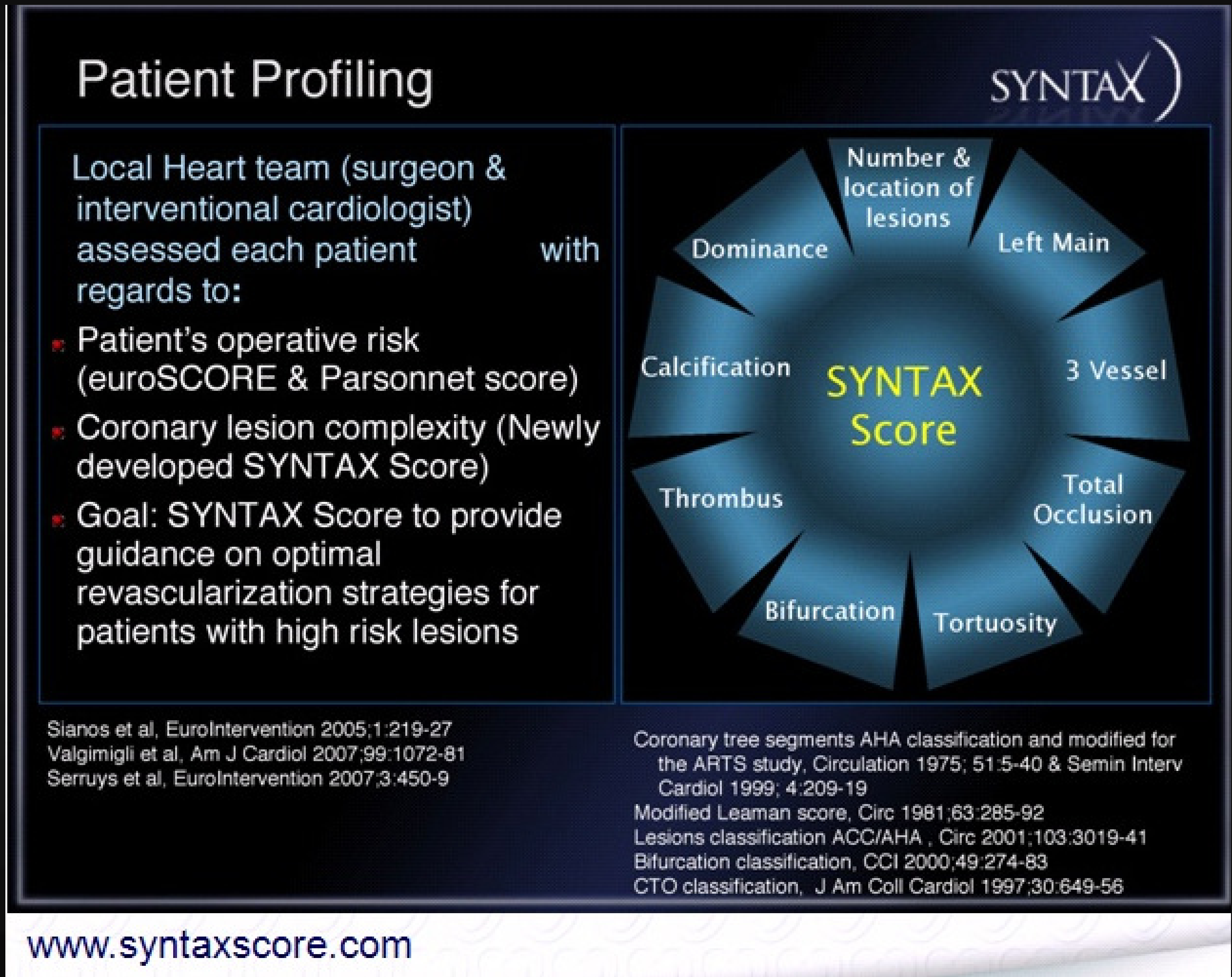




Ferrante G et al, EuroIntervention 11.2011

# The Guidelines and Appropriateness Criteria

# LM Assessment: ESC Guidelines




Wijns W et al, EHJ 10.2010

# LM Assessment: ESC Guidelines

## Recommendations for decision making and patient information

| | Class | Level |
|---|---|---|
| It is recommended that patients be adequately informed about the potential benefits and short- and long-term risks of a revascularisation procedure. Enough time should be spared for informed decision making. | I | C |
| The appropriate revascularisation strategy in patients with MVD should be discussed by the Heart Team. | I | C |

Wijns W et al, EHJ 10.2010

# Indications for CABG versus PCI in stable patients with lesions suitable for both procedures and low predicted surgical mortality

| Subset of CAD by anatomy | Favours CABG | Favours PCI |
|---|---|---|
| 1VD or 2VD - non-proximal LAD | IIb C | I C |
| 1VD or 2VD - proximal LAD | I A | IIa B |
| 3VD simple lesions, full functional revascularisation achievable with PCI, SYNTAX score ≤ 22 | I A | IIa B |
| 3VD complex lesions, incomplete revascularisation achievable with PCI, SYNTAX score > 22 | I A | III A |
| Left main (isolated or 1VD, ostium/shaft) | I A | IIa B |
| Left main (isolated or 1VD, distal bifurcation) | I A | IIb B |
| Left main + 2VD or 3VD, SYNTAX score ≤ 32 | I A | IIb B |
| Left main + 2VD or 3VD, SYNTAX score ≥ 33 | I A | III B |

www.escardio.org/guidelines

Joint 2010 ESC - EACTS Guidelines on Myocardial Revascularisation

EACTS

EUROPEAN SOCIETY OF CARDIOLOGY®

Wijns W et al, EHJ 10.2010

# LM Revasc: Appropriateness Criteria

## Appropriateness of revascularisation method for advanced coronary artery disease

### ACCF / SCAI / STS / AATS / AHA / ASNC 2009 report

| | CABG | | | PCI | | |
|---|---|---|---|---|---|---|
| | No diabetes and normal LVEF | Diabetes | Depressed LVEF | No diabetes and normal LVEF | Diabetes | Depressed LVEF |
| Two vessel coronary artery disease with proximal LAD stenosis | A | A | A | A | A | A |
| Three vessel coronary artery disease | A | A | A | U | U | U |
| Isolated left main stenosis | A | A | A | I | I | I |
| Left main stenosis and additional coronary artery disease | A | A | A | I | I | I |

Patel MR et al. JACC 2009;53:530-53.

# Heart Team Approach to UPLM or Complex CAD

| Anatomic Setting | COR | LOE |
|---|---|---|
| UPLM or Complex CAD | I – Heart Team Approach | C |
| UPLM or Complex CAD | IIa – Calculation of the STS and SYNTAX scores | B |

Levine GN et al, JACC 12.2011

# UPLM Revascularization to Improve Survival

| Revasc Method | COR | LOE |
|---|---|---|
| CABG | I | B |
| PCI | IIa—For SIHD when *both* of the following are present:<br>•Anatomic conditions associated with a low risk of PCI procedural complications and a high likelihood of good long-term outcome (e.g., a low SYNTAX score of ≤22, ostial or trunk left main CAD)<br>•Clinical characteristics that predict a significantly increased risk of adverse surgical outcomes (e.g., STS-predicted risk of operative mortality ≥5%) | B |
| | IIa—For UA/NSTEMI if not a CABG candidate | B |
| | IIa—For STEMI when distal coronary flow is <TIMI grade 3 and PCI can be performed more rapidly and safely than CABG | C |
| | IIb—For SIHD when *both* of the following are present:<br>•Anatomic conditions associated with a low to intermediate risk of PCI procedural complications and an intermediate to high likelihood of good long-term outcome (e.g., low-intermediate SYNTAX score of <33, bifurcation left main CAD)<br>•Clinical characteristics that predict an increased risk of adverse surgical outcomes (e.g., moderate-severe COPD, disability from prior stroke, or prior cardiac surgery; STS-predicted operative mortality >2%) | B |
| | III: Harm—For SIHD in patients (versus performing CABG) with unfavorable anatomy for PCI and who are good candidates for CABG | B |

Levine GN et al, JACC 12.2011

# UPLM Revascularization to Improve Survival

| Revasc Method | COR | LOE |
|---|---|---|
| **CABG** | I | B |
| **PCI** | IIa—For SIHD when low risk of PCI complications and high likelihood of good long-term outcome (e.g., SYNTAX score of ≤22, ostial or trunk left main CAD), **and** a signficantly increased CABG risk (e.g., STS-predicted risk of operative mortality ≥5%) | B |
| | IIb—For SIHD when low to intermediate risk of PCI complications and intermediate to high likelihood of good long-term outcome (e.g., SYNTAX score of <33, bifurcation left main CAD) **and** increased CABG risk (e.g., moderate-severe COPD, disability from prior stroke, prior cardiac surgery, STS-predicted operative mortality >2%) | B |
| | III: Harm—For SIHD in patients (versus performing CABG) with unfavorable anatomy for PCI and who are good candidates for CABG | B |
| | IIa—For UA/NSTEMI if not a CABG candidate | B |
| | IIa—For STEMI when distal coronary flow is <TIMI grade 3 and PCI can be performed more rapidly and safely than CABG | C |

Levine GN et al, JACC 12.2011

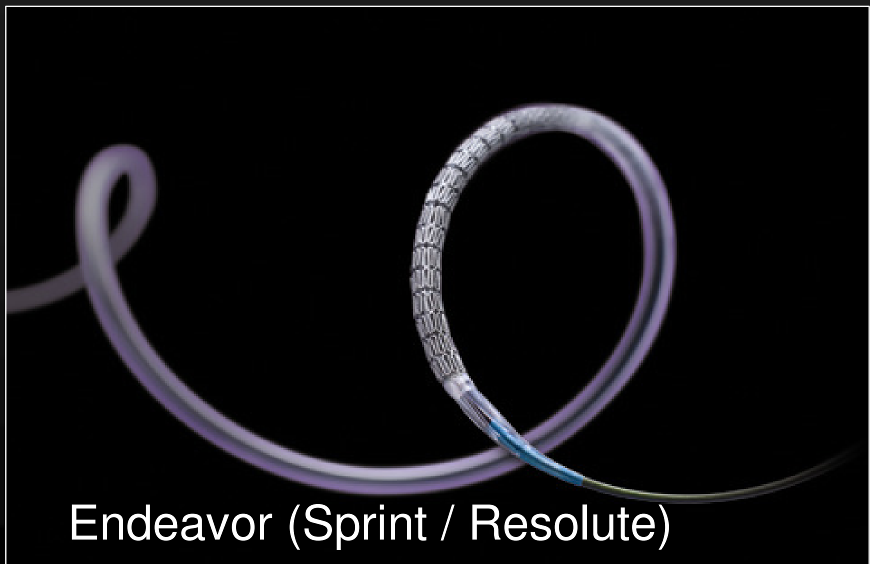
# UPLM PCI to Improve Survival (ACS)

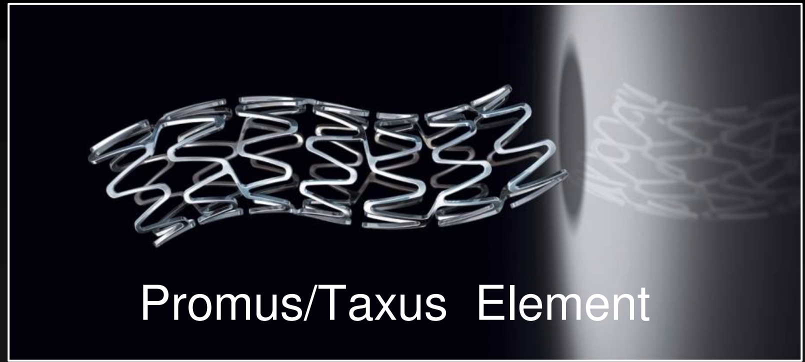
| COR | LOE |
|---|---|
| IIa—For UA/NSTEMI if not a CABG candidate | B |
| IIa—For STEMI when distal coronary flow is <TIMI grade 3 and PCI can be performed more rapidly and safely than CABG | C |

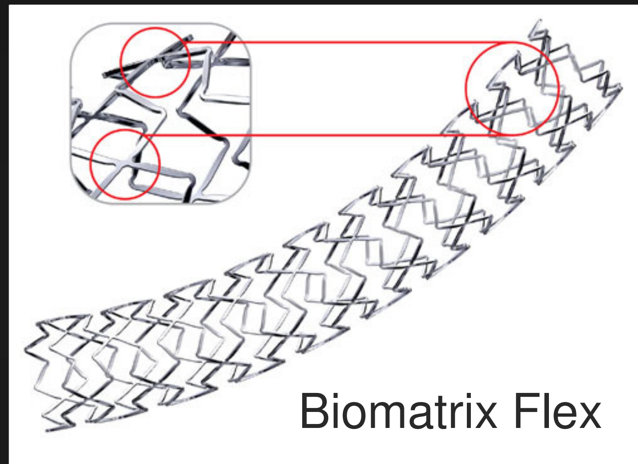
Levine GN et al, JACC 12.2011

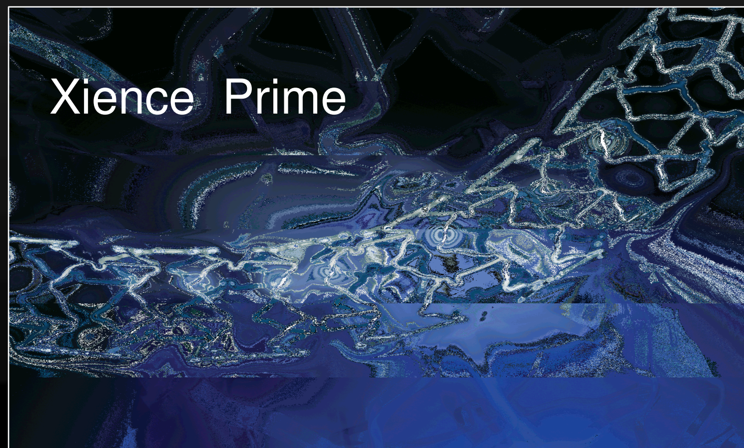
# Stent Type (DESs)


Cypher select+

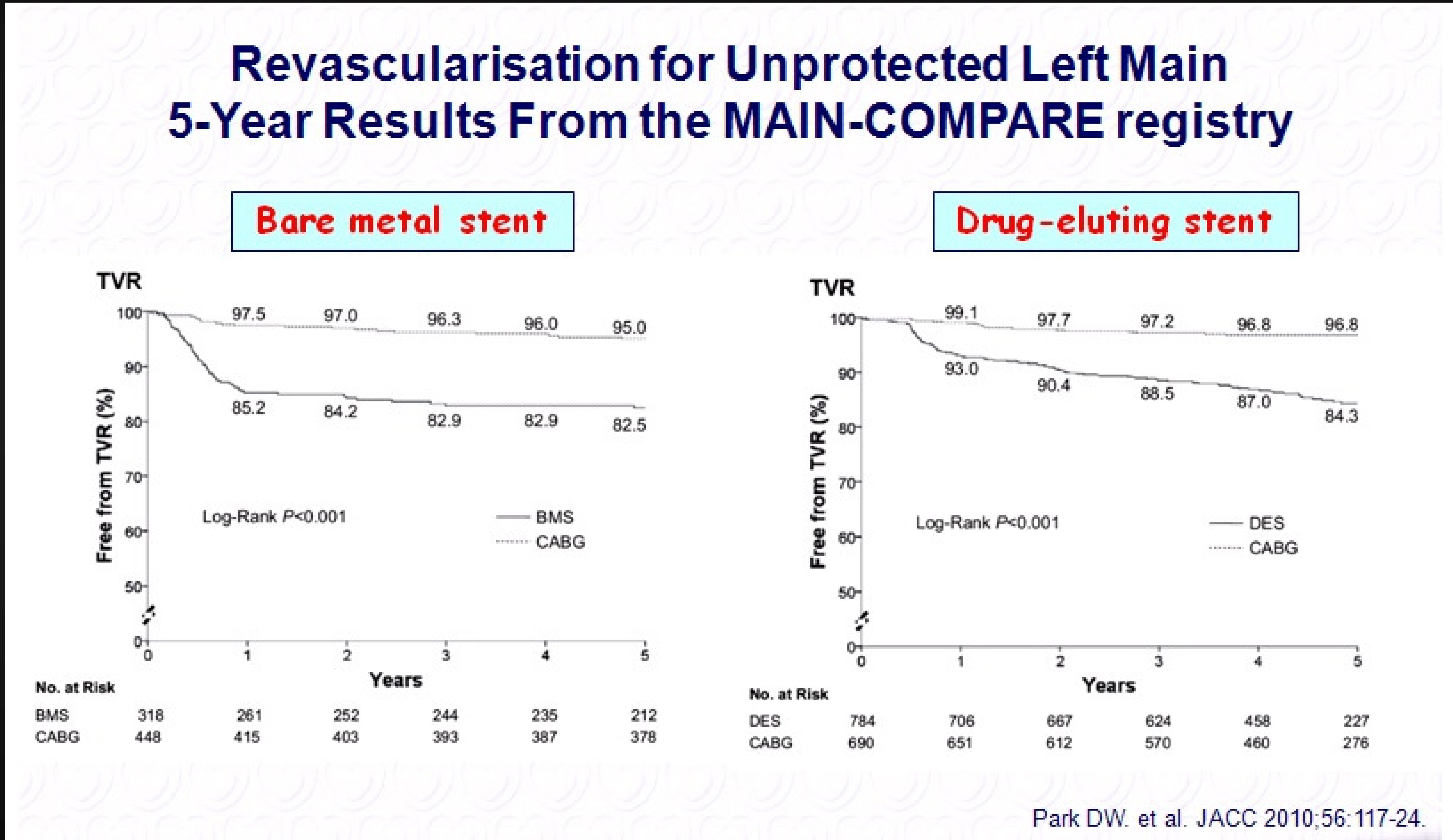

Endeavor (Sprint / Resolute)


Promus/Taxus Element


Biomatrix Flex


Xience Prime

# Stent Type: DES vs. BMS

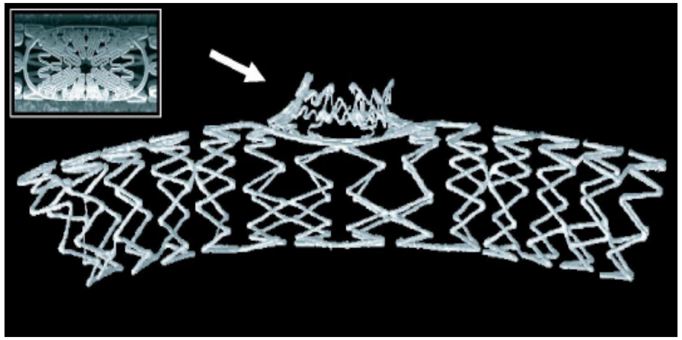


# Clinical Situations Associated With DES or BMS Selection Preference

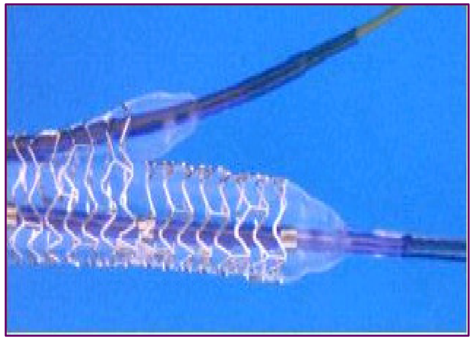
| DES Generally Preferred Over BMS (efficacy considerations) | BMS Preferred Over DES (safety considerations) |
|---|---|
| • Left main disease<br>• Small vessels<br>• In-stent restenosis<br>• Bifurcation lesions<br>• Long lesions<br>• Multiple lesions<br>• Saphenous vein graft lesions<br>• Diabetic patients | • Patients unable to tolerate or comply with prolonged DAPT<br>• Anticipated surgery requiring discontinuation of DAPT within 12 months<br>• High risk of bleeding |

Levine GN et al, JACC 12.2011

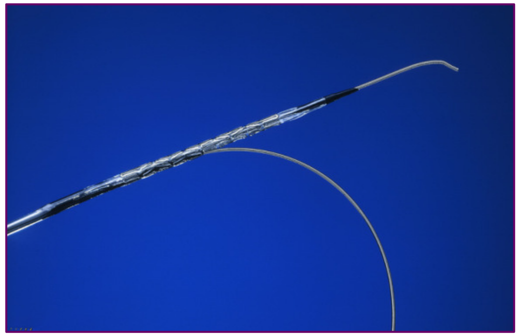
# Dedicated LM bifurcation techniques?



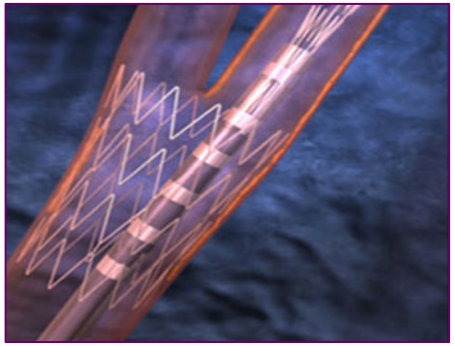
TAXUS petal



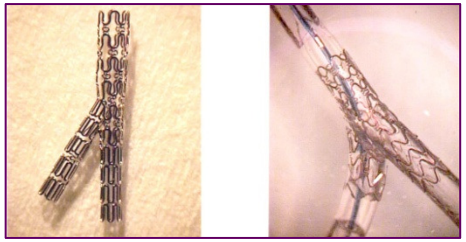
Guidant frontier



YMed sidekick

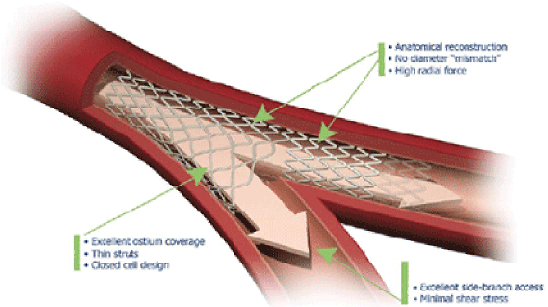


Devax (+ BA9)



“true” bifurcation designs

sidebranch designs




Stentys

Tryton

# Left Main PCI

## Dedicated techniques, stents, and operators

- It is always about the operator, his/her ethics, experience, passion, responsibility, skills, dedication and awareness of procedural limitations.
- Always do it for the patient!

# Thank You