How To Do the Best LM Stenting?

Functional Evaluation is Necessary!

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Visual Functional Mismatch

Visual: 80%

FFR: 0.82
Treadmill test: Negative
Thallium spect: Normal
Stress Echo: Negative
Reverse Mismatch

Visual Estimation: 30%

Angiography is Not Always Enough!

Thallium spect: + large LAD

Treadmill test: + stage 2

FFR: 0.70

IVUS MLA: 4.5 mm²

Reverse Mis match

Angiography is Not Always Enough!
How Many Mismatches ?
Mismatch in intermediate LM Disease

Hamilos M, Circulation 2009; 120: 1505-1512
Mismatch
Intermediate LM Ostial and Shaft Disease
(AMC data, n=112)

Overall 37% of Ostial and Shaft lesions showed Mismatches.
The Reason Why **Functional Evaluation is Necessary**!
Why Mismatches?
Multivariable Analysis to Predict Mismatches, **Non-LM**

IVUS Analysis of Prospective Cohort 1000 Patients

### Mismatch

- Significant Stenosis (>50%)
- Negative FFR (>0.80)

<table>
<thead>
<tr>
<th>Older Age</th>
<th>Younger Age</th>
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<tbody>
<tr>
<td>Non-LAD location</td>
<td>LAD location</td>
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<tr>
<td>Shorter lesion length</td>
<td>Plaque Rupture</td>
</tr>
<tr>
<td>Larger MLA by IVUS</td>
<td>Smaller MLA by IVUS</td>
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<tr>
<td>Larger MLD by QCA</td>
<td>Larger PB</td>
</tr>
<tr>
<td>Smaller PB</td>
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</tbody>
</table>

### Reverse Mismatch

- Insignificant Stenosis (<50%),
  - Positive FFR (<0.80)

<table>
<thead>
<tr>
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Park SJ et al, JACC Intv 2012;5:1029–36
### Multivariable Analysis to Predict FFR <0.80, LM (n=112)

<table>
<thead>
<tr>
<th>Variables</th>
<th>OR</th>
<th>95%CI</th>
<th>p-value</th>
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<tbody>
<tr>
<td><strong>Model 1</strong></td>
<td></td>
<td></td>
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<tr>
<td>Plaque rupture</td>
<td>4.51</td>
<td>1.36-14.9</td>
<td>0.014</td>
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<td>BMI, kg/m²</td>
<td>1.19</td>
<td>1.00-1.40</td>
<td>0.05</td>
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<td>Age, year</td>
<td>0.95</td>
<td>0.90-1.00</td>
<td>0.033</td>
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<tr>
<td>MLA, mm²</td>
<td>0.37</td>
<td>0.25-0.56</td>
<td>&lt;0.001</td>
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<td><strong>Model 2</strong></td>
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<tr>
<td>LV mass, g</td>
<td>1.01</td>
<td>1.00-1.03</td>
<td>0.03</td>
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<tr>
<td>Age, year</td>
<td>0.94</td>
<td>0.90-0.99</td>
<td>0.022</td>
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<tr>
<td>MLA, mm²</td>
<td>0.34</td>
<td>0.21-0.54</td>
<td>&lt;0.001</td>
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</table>

Model 1 included clinical, QCA, and IVUS variables
Model 2 included Model 1 plus LV mass assessed by Echocardiography
Reverse **Mismatch**

Visual Estimation
30% DS

FFR : 0.70

Plaque Rupture, Smaller MLA and Large LV mass (Myocardium) Are Related with Positive FFR.

Plaque rupture, MLA 6.2mm$^2$
Why FFR?

Accurate Diagnosis First!
To Treat or Not To Treat Concerns
Is FFR Cut-Off 0.80, Validated in LM Disease Too?
Validation of FFR Cut-Off for LM Disease; 0.74
(Matched with Thallium Perfusion Scan, n=38)

0.80 FFR Cut-Off Would Be Appropriate for LM Disease Too.
How I Implement FFR in Real Practice?
For the Undetermined, Intermediate Ostial and Shaft LM Lesion,

FFR is Crucial
For the Intermediate LM Bifurcation Lesion,

If Transducer Placed Beyond Bifurcation in both LAD and LCX,

Single Unit of Disease

Composite FFR still Works.
Why IVUS Is Necessary Too?
Angiographic 80% LM Ostial Disease, And, Patient received CABG, But, IVUS finding is Free of Disease.

Angiography Is **Not Always Enough**, To Define Clinical Ischemia.
IVUS Is Recommended

1. Assessment of LM Ostium, Reference Vessel Diameter, Pattern of Remodeling, and Vulnerability of Plaque.
LM Bifurcation Disease
with Minimal LCX Disease

55/M, Stable angina, TMT (+), Thallium scan (-)
By IVUS, Reference Vessel Diameters of LM and LAD are Bigger than Angiographic Assessment, and the LCX ostium Showed Free of Disease.

Minimal disease at LCX ostium
We Did Just **Single Stent Cross-Over**!

- Promus Element 4.0x20
- Additional high pressure inflation with 4.0 mm non-compliant balloon

LM-LAD cross over
After Stent Cross-Over, LCX Ostium Was Jailed!

What Would You Do?
Do You Want to Treat Jailed Side Branch?
Consider FFR, First!

Just Defer!
It’s Safe and Effective.
**Why IVUS Too?**

1. Assessment of LM Ostium, Reference Vessel Diameter, Pattern of Remodeling, and Vulnerability of Plaque.
3. IVUS Guided Stent Optimization and Effective Stent CSA Can Make a Good Clinical Outcomes.
4. IVUS Guidance Reduced Death/MI and Saved Lives.
IVUS Stent Area to Reduce Restenosis (Rule of 5,6,7,8)

Restenosis Rate < 5%,
TLR < 2%
IVUS Guidance Saves Lives in LM PCI

Can **IVUS MLA** Predict the Functional Significance of Stenosis In LM Disease?
IVUS MLA < 6.0 mm² is matched with FFR < 0.75

Why 6 mm$^2$ IVUS MLA Is Not Appropriate?
Background, Geometric Abstraction

“The 6-mm\(^2\) value was obtained from Murray’s law (considering an MLA of 4 mm\(^2\) as the ischemic threshold of the branches) and has been supported by a study that used IVUS and pressure wire flow fractional reserve (FFR).”

De La Torre Hernandez et al. JACC 2011;58:351-8
### IVUS MLA Matched with FFR, Non-LM

#### New Published Data

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<tr>
<th></th>
<th>N</th>
<th>FFR</th>
<th>RLA</th>
<th>MLA mm²</th>
<th>AUC</th>
<th>Sens</th>
<th>Spec</th>
<th>PPV</th>
<th>NPV</th>
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<td>0.75</td>
<td>7.8</td>
<td>4.0</td>
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<td>56%</td>
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<td>64%</td>
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<td><strong>Takaki</strong></td>
<td>51</td>
<td>0.75</td>
<td>9.3</td>
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<td>83%</td>
<td>92%</td>
<td>–</td>
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<td>8.6</td>
<td>3.07</td>
<td>0.65</td>
<td>64%</td>
<td>65%</td>
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<td><strong>Kang</strong></td>
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<td>8.2</td>
<td>2.4</td>
<td>0.77</td>
<td>84%</td>
<td>63%</td>
<td>48%</td>
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<td><strong>Kang</strong></td>
<td>236</td>
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<td>2.4</td>
<td>0.80</td>
<td>90%</td>
<td>60%</td>
<td>37%</td>
<td>96%</td>
<td>68%</td>
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<td><strong>Gonzalo</strong></td>
<td>61</td>
<td>0.80</td>
<td>7.1</td>
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<td>0.70</td>
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<td>66%</td>
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<td><strong>Koo</strong></td>
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<td>0.81</td>
<td>69%</td>
<td>65%</td>
<td>27%</td>
<td>81%</td>
<td>67%</td>
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<td><strong>Lee</strong></td>
<td>94</td>
<td>0.75</td>
<td>5.9</td>
<td>2.0</td>
<td>0.80</td>
<td>82%</td>
<td>81%</td>
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Murray’s Law, **Finet’s Law**, Huo and Kassab (HK)’s Law,

Ischemic Threshold of Branches Would Be $< 3 \text{ mm}^2$ Based on the Current Data. The 6 mm$^2$ of IVUS MLA is Not Appropriate Anymore from Geometric Abstraction with Murray’s Law, Finet’s Law, and HK’s Law.

New IVUS MLA
In LM Disease (n=112)

AMC FFR Registry, New Data
New LM IVUS MLA
Matched with FFR <0.80, Ostial and Shaft LM Disease

(n=55 lesions)

Cut-off = 4.8 mm²

- Sensitivity: 89%
- Specificity: 83%
- PPV: 82%
- NPV: 89%
- Accuracy: 86%

(n=112 lesions)

Cut-off = 4.5 mm²

- Sensitivity: 79%
- Specificity: 80%
- PPV: 83%
- NPV: 76%
- Accuracy: 80%
Jasti’s data (n=55)

1. Small Number
2. Large Vessels,
3. 75% Negative FFR
4. Not Normal Distribution
Jasti’s data (n=55)

AMC New Data (n=112)

1. Small Number
2. Large Vessels,
3. 75% Negative FFR
4. Not Normal Distribution

More Positive FFR
Normal Distribution

MLA (mm$^2$)

4.5 mm$^2$
In Practice,

Smaller LM IVUS MLA of 4.5 mm$^2$ Can Predict Functional Significance of Stenosis (PPV 83%).
Why IVUS Too?

1. Assessment of LM Ostium, Reference Vessel Diameter, Pattern of Remodeling, and Vulnerability of Plaque.
3. IVUS Guided Stent Optimization and Effective Stent CSA Can Make a Good Clinical Outcomes.
4. IVUS Guidance Reduced Death/MI and Saved Lives.
5. Smaller IVUS MLA 4.5 mm² Can Predict Functional Significance of LM Stenosis.
IVUS assessment of Both LAD and LCX is recommended!

LM Bifurcation Stenting

- Single Stent
  - After Stent Cross-Over
  - Do You Want to Treat the Jailed Side Branch?
  - How to Treat?

- Any 2 Stent
  - How to Optimize?

IVUS Minimal Stent CSA Criteria 5-6-7-8 mm² may improve long-term clinical outcomes.
Why FFR and IVUS?

1. FFR Guided Decision Making.
2. IVUS Guided Sent Optimization.
3. They are Complementary for the Good Clinical Outcomes.