Coronary Intervention; Future Perspective

Paradigm Shift to Functional PCI

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Functional PCI

Smart In-corporation of recent Evidences into Clinical Practice.
Functional PCI

Treat or Not treat:
FFR guided - Decision making
(Physiologic assessment)

How to treat:
IVUS guided - Optimizing procedure
(Anatomical optimization)
Functional PCI

Treat or Not treat:
FFR guided - Decision making
(Physiologic assessment)
A Case
M/58, Atypical chest pain, Hyperlipidemia, Ex-smoker
Treat or Not treat?

Visual Estimation
80%
QCA: 56%
IVUS

MLA : 3.2 mm$^2$
Ref. VD : 4.5 mm
Plaque Burden : 80.2%
Treat or Not treat?

Visual Estimation: 80%
IVUS: MLA 3.2 mm²
Plaque Burden: 80.2%
FFR
(intravenous adenosine, 140 µg/kg/min)
Stage 4 - Negative
Thallium Spect; Normal
Visual Estimation : 80%
IVUS : MLA 3.2 mm²
FFR : 0.91
Treadmill test : Negative
Thallium spect : Normal

Do you still want to treat ?
M/74, Multiple stenosis on Coronary CT, Silent ischemia, Hypertension, DM, Hyperlipidemia, Ex-smoker,

Visual Estimation: 60% Ruptured Plaque
**IVUS**  
(LAD pullback)

MLA: 3.8 mm²

MLA: 3.2 mm²
Exclude thrombi & plaque rupture
Treat or Not treat?

Visual Estimation: 60%
IVUS: MLA 3.8-3.2mm²
VH-IVUS: Ruptured Plaque with large necrotic core
FFR
(intravenous adenosine, 140 µg/kg/min)
M/74,

Visual Estimation: 60%
IVUS: MLA 3.8-3.2mm²
VH-IVUS: Ruptured Plaque with large necrotic core
Thallium scan: Normal

Do you want to treat?
What you see may not be everything. Looks can be deceiving.

FFR > 0.8 is a really perfect surrogate for absence of clinical ischemia. (Specificity 100%, Sensitivity 88%)
Milestone Study
DEFER 5 Year Results

Event Free Survival

Cardiac Death and MI

Pijls et al. J am Coll Cardiol 2007;49:2105-11
FAME

Fractional Flow Reserve
VS Angiography
for Multivessel Evaluation

## FAME: Procedural Results

<table>
<thead>
<tr>
<th></th>
<th>ANGIO-group N=496</th>
<th>FFR-group N=509</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong># indicated lesions per patient</strong></td>
<td>2.7 ± 0.9</td>
<td>2.8 ± 1.0</td>
<td>0.34</td>
</tr>
<tr>
<td><strong>FFR results</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lesions successfully measured, No (%)</td>
<td>-</td>
<td>1329 (98%)</td>
<td>-</td>
</tr>
<tr>
<td>Lesions with FFR ≤ 0.80, No (%)</td>
<td>-</td>
<td>874 (63%)</td>
<td>-</td>
</tr>
<tr>
<td>Lesions with FFR &gt; 0.80, No (%)</td>
<td>-</td>
<td>513 (37%)</td>
<td>-</td>
</tr>
<tr>
<td><strong>Stents per patient</strong></td>
<td>2.7 ± 1.2</td>
<td>1.9 ± 1.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Lesions successfully stented (%)</td>
<td>92%</td>
<td>94%</td>
<td>-</td>
</tr>
<tr>
<td>DES, total, No</td>
<td>1359</td>
<td>980</td>
<td>-</td>
</tr>
</tbody>
</table>
2 Year Survival Free of MACE
MACE: Composite of Death, Myocardial Infarction, or Repeat Revascularization

Late Breaking Trial, TCT 2009
Why FFR guided?

- Avoid unnecessary procedures
- Avoid unnecessary surgery
- Minimize MACE
- Maximize clinical outcomes
- Save money
- Save lives
How to treat:
IVUS guided - Optimizing procedure
(Anatomical optimization)
Why IVUS guided?

IVUS guidance Saves Lives!!
Usefulness of IVUS study
In the era of BMS
### Combined Endpoints (Death & MI) at 6 Mo

#### Meta-analysis (N=2972)

<table>
<thead>
<tr>
<th>Study</th>
<th>IVUS-guided</th>
<th>Angio-guided</th>
<th>Odds ratios and 95% CI Fixed</th>
<th>OR and 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Radonimizedtrials</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIPS,1996</td>
<td>5/121 (4.1%)</td>
<td>0/148 (6.7%)</td>
<td></td>
<td>0.59 (0.20-1.79)</td>
</tr>
<tr>
<td>RESIST. 1997</td>
<td>1/79 (1.2%)</td>
<td>1/76 (1.3%)</td>
<td></td>
<td>0.96 (0.06-15.65)</td>
</tr>
<tr>
<td>OPTICUS.1998</td>
<td>9/273 (3.3%)</td>
<td>10/277 (3.6%)</td>
<td></td>
<td>0.91 (0.36-2.28)</td>
</tr>
<tr>
<td>AVID. 1999</td>
<td>25/372 (6.7%)</td>
<td>17/387 (4.4%)</td>
<td></td>
<td>1.57 (0.83-2.95)</td>
</tr>
<tr>
<td>TULIP. 2001</td>
<td>1/73 (1.3%)</td>
<td>5/77 (6.5%)</td>
<td></td>
<td>0.20 (0.02-1.75)</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>41/918 (4.4%)</td>
<td>43/965 (4.4%)</td>
<td></td>
<td>1.02 (0.65-1.57)</td>
</tr>
<tr>
<td><strong>Registries</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Albiero et al. 1995</td>
<td>5/18 (3.1%)</td>
<td>0.15 (0%)</td>
<td></td>
<td>11.07 (0.61-201.97)</td>
</tr>
<tr>
<td>Choi et al. 1997</td>
<td>4/178 (2.2%)</td>
<td>1/100 (1%)</td>
<td></td>
<td>2.28 (0.25-20.65)</td>
</tr>
<tr>
<td>CRUISE. 2000</td>
<td>19/270 (7%)</td>
<td>16/229 (7%)</td>
<td></td>
<td>1.01 (0.51-2.01)</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>28/606 (4.6%)</td>
<td>17/483 (3.5%)</td>
<td></td>
<td>1.37 (0.74-2354)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>69/1,524 (4.5%)</td>
<td>60/1,448 (4.1%)</td>
<td></td>
<td>1.13 (0.79-1.61)</td>
</tr>
</tbody>
</table>

IVUS-guided better

Angio-guided better

p=0.5

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### Binary Restenosis at 6 Mo

Meta-analysis (N=2972)

<table>
<thead>
<tr>
<th>Study</th>
<th>IVUS-guided</th>
<th>Angio-guided</th>
<th>OR and 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Randomized trials</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIPS, 1996</td>
<td>48/166 (29%)</td>
<td>66/190 (34.7%)</td>
<td>0.76 (0.49-1.20)</td>
</tr>
<tr>
<td>RESIST, 1997</td>
<td>17/71 (22.5%)</td>
<td>21/73 (28.7%)</td>
<td>0.72 (0.34-1.53)</td>
</tr>
<tr>
<td>OPTICUS, 1998</td>
<td>56/229 (24.4%)</td>
<td>52/228 (22.8%)</td>
<td>1.10 (0.71-1.69)</td>
</tr>
<tr>
<td>TULIP, 2001</td>
<td>15/73 (20.5%)</td>
<td>28/77 (36.4%)</td>
<td>0.45 (0.22-0.94)</td>
</tr>
<tr>
<td>Subtotal</td>
<td>135/539 (25%)</td>
<td>167/568 (29%)</td>
<td>0.81 (0.62-1.06)</td>
</tr>
<tr>
<td><strong>Registries</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Albiero et al, 1995</td>
<td>29/158 (18.3%)</td>
<td>40/154 (26%)</td>
<td>0.64 (0.37-1.10)</td>
</tr>
<tr>
<td>Blasini et al, 1995</td>
<td>22/105 (20.9%)</td>
<td>32/107 (29.9%)</td>
<td>0.62 (0.33-1.16)</td>
</tr>
<tr>
<td>Subtotal</td>
<td>51/263 (19%)</td>
<td>72/261 (27.5%)</td>
<td>0.63 (0.42-0.95)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>186/802 (23%)</td>
<td>239/829 (28.8%)</td>
<td><strong>0.75 (0.60-0.94)</strong></td>
</tr>
</tbody>
</table>

IVUS-guided better | Angio-guided better

### p=0.01

Substantial **25% reduction** of binary restenosis in IVUS-guided stenting

Usefulness of IVUS study
In the era of DES
IVUS-guidance vs. Angio-guidance
(Propensity–Matched) in DES-Treated Lesions

<table>
<thead>
<tr>
<th></th>
<th>IVUS-guided</th>
<th>Angio-guided</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>30-day</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MACE</td>
<td>2.8%</td>
<td>5.2%</td>
<td>0.010</td>
</tr>
<tr>
<td>ST</td>
<td>0.5%</td>
<td>1.4%</td>
<td>0.046</td>
</tr>
<tr>
<td>TLR</td>
<td>0.7%</td>
<td>1.7%</td>
<td>0.050</td>
</tr>
<tr>
<td><strong>1-year</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MACE</td>
<td>14.5%</td>
<td>16.2%</td>
<td>0.330</td>
</tr>
<tr>
<td>Definite ST</td>
<td>0.7%</td>
<td>2.0%</td>
<td>0.014</td>
</tr>
<tr>
<td>Probab ST</td>
<td>4.0%</td>
<td>5.8%</td>
<td>0.080</td>
</tr>
<tr>
<td>TLR</td>
<td>5.1%</td>
<td>7.2%</td>
<td>0.070</td>
</tr>
<tr>
<td>Late ST</td>
<td>0.2%</td>
<td>0.7%</td>
<td>0.160</td>
</tr>
</tbody>
</table>

Stent Thrombosis Free Survival (%)

P=0.013
**IVUS-Guided** \((n=952)\) **vs. Angio-Guided** \((n=398)\) **in the era of DES**

<table>
<thead>
<tr>
<th></th>
<th>IVUS-guided</th>
<th>Angio-guided</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>63.4±0.36 yrs</td>
<td>63.5±0.42 yrs</td>
<td></td>
</tr>
<tr>
<td><strong>Diabetes</strong></td>
<td>27%</td>
<td>35%</td>
<td>0.007</td>
</tr>
<tr>
<td><strong>ACS</strong></td>
<td>26%</td>
<td>27%</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Multivessel disease</strong></td>
<td>54%</td>
<td>45%</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>LAD</strong></td>
<td>46%</td>
<td>15%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Stents/lesion</strong></td>
<td>1.01</td>
<td>1.04</td>
<td>NS</td>
</tr>
<tr>
<td><strong>%DES</strong></td>
<td>93%</td>
<td>81%</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>Stent diameter (mm)</strong></td>
<td>3.0±0.4</td>
<td>2.9±0.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Stent length (mm)</strong></td>
<td>24.0±7.4</td>
<td>22.9±7.8</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Costantini et al. TCT 2008
Thrombosis Free Survival at 3 year F/U

TVF Free Survival

Log-Rank Test p=0.04

Log-Rank Test p=0.02

Costantini et al. TCT 2008
IVUS guided procedure in the era of DES – Matched registry data

Survival Benefit!
Unselected “Real World” PCI Registry

IVUS guided vs. Angio-guided

(n=8371, 2 centers registry)
Overall population
N=8371

DES 2003-2006
BMS 1998-2003

IVUS guidance
N=4627

Angio guidance
N=3744

DES Population
N=4581

BMS Population
N=3790

All cause death, MI, TVR, Stent thrombosis, MACE
Death

Overall Population

Event-free Survival (%)

Months after Initial Procedure

Unadjusted K-M Curves

Log-Rank test, p<0.001

IVUS guidance PCI

Angiography guidance PCI

0 12 24 36

98.6 97.3 96.5
97.0 95.3 93.8
Cardiac Death

Overall Population

Event-free Survival (%)

Log-Rank test, $p<0.001$

- IVUS guidance PCI
- Angiography guidance PCI

Months after Initial Procedure
## Hazard Ratios of Clinical Outcomes

*IVUS guidance  vs. Angiography guidance*

### Overall Population

<table>
<thead>
<tr>
<th>Event</th>
<th>Multivariate Adjusted HR (95% CI)</th>
<th>p</th>
<th>Adjusted for Propensity HR (95% CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>0.49 (0.34-0.71)</td>
<td>&lt;0.01</td>
<td>0.66 (0.53-0.83)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Cardiac death</td>
<td>0.46 (0.28-0.76)</td>
<td>&lt;0.01</td>
<td>0.58 (0.41-0.81)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>MI</td>
<td>1.01 (0.65-1.58)</td>
<td>0.96</td>
<td>1.08 (0.71-1.63)</td>
<td>0.73</td>
</tr>
<tr>
<td>TVR</td>
<td>0.97 (0.83-1.13)</td>
<td>0.66</td>
<td>1.05 (0.90-1.22)</td>
<td>0.54</td>
</tr>
<tr>
<td>ST</td>
<td>0.87 (0.60-1.27)</td>
<td>0.48</td>
<td>0.83 (0.58-1.17)</td>
<td>0.29</td>
</tr>
<tr>
<td>MACE</td>
<td>0.89 (0.77-1.02)</td>
<td>0.09</td>
<td>0.92 (0.81-1.05)</td>
<td>0.21</td>
</tr>
</tbody>
</table>
DES Population

N = 4581 Patients
Death

DES Population

Event-free Survival (%)

Months after Initial Procedure

Log-Rank test, $p<0.001$

Unadjusted K-M Curves

- IVUS guidance PCI
- Angiography guidance PCI
Cardiac Death

DES Population

Event-free Survival (%)

Log-Rank test, $p=0.003$

- IVUS guidance PCI
- Angiography guidance PCI

Months after Initial Procedure
Death

**DES Population**

- **IVUS guidance PCI**
- **Angiography guidance PCI**

Event Rate (%) vs Months after Initial Procedure:

- **Death**
  - **p < 0.001**
  - **p = 0.284**
  - **p = 0.01**
Cardiac Death

DES Population

- IVUS guidance PCI
- Angiography guidance PCI

Event Rate (%)

* $p < 0.001$
* $p = 0.90$
* $p = 0.01$

Months after Initial Procedure
# Hazard Ratios of Clinical Outcomes

**IVUS guidance vs. Angiography guidance**

## DES Population

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Multivariate Adjusted</th>
<th></th>
<th>Adjusted for Propensity</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HR (95% CI)</td>
<td>( p )</td>
<td>HR (95% CI)</td>
<td>( p )</td>
</tr>
<tr>
<td>Death</td>
<td>0.52 (0.37-0.73)</td>
<td>&lt;0.01</td>
<td>0.50 (0.36-0.70)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Cardiac death</td>
<td>0.46 (0.28-0.76)</td>
<td>&lt;0.01</td>
<td>0.47 (0.29-0.75)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>MI</td>
<td>0.43 (0.16-1.14)</td>
<td>0.09</td>
<td>0.21 (0.28-1.32)</td>
<td>0.21</td>
</tr>
<tr>
<td>TVR</td>
<td>1.00 (0.75-1.34)</td>
<td>0.99</td>
<td>1.04 (0.80-1.35)</td>
<td>0.79</td>
</tr>
<tr>
<td>ST</td>
<td>0.87 (0.52-1.47)</td>
<td>0.61</td>
<td>0.77 (0.48-1.23)</td>
<td>0.28</td>
</tr>
<tr>
<td>MACE</td>
<td>0.75 (0.60-0.95)</td>
<td>0.01</td>
<td>0.78 (0.64-0.95)</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Although we have the limitation of registry data, 45-50 % relative reduction of cardiac mortality in IVUS guided procedure is very substantial in the era of DES.
BMS Population

N = 3790 Patients
### Hazard Ratios of Clinical Outcomes

**IVUS guidance vs. Angiography guidance**

#### BMS Population

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Multivariate Adjusted</th>
<th>Adjusted for Propensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HR (95% CI)</td>
<td>p</td>
</tr>
<tr>
<td>Death</td>
<td>0.88 (0.64-1.21)</td>
<td>0.42</td>
</tr>
<tr>
<td>Cardiac death</td>
<td>0.96 (0.58-1.58)</td>
<td>0.86</td>
</tr>
<tr>
<td>MI</td>
<td>1.43 (0.87-2.36)</td>
<td>0.16</td>
</tr>
<tr>
<td>TVR</td>
<td>1.14 (0.95-1.38)</td>
<td>0.15</td>
</tr>
<tr>
<td>ST</td>
<td>0.98 (0.57-1.67)</td>
<td>0.93</td>
</tr>
<tr>
<td>MACE</td>
<td>1.09 (0.92-1.30)</td>
<td>0.31</td>
</tr>
</tbody>
</table>
IVUS Guidance gives...

Death or MI vs Complexity

Paradigm Shift in the era of DES

- BMS: No Survival Benefit
- DES: Survival Benefit

Complicated Patients
Complex Lesions
Complex Procedures
IVUS guided procedure
in the era of DES - Various Registry data -

Constantly reduced long-term mortality!
IVUS guided procedures have Better Survival…

Can you explain this?

Small difference made by IVUS guidance can make a big difference in the late clinical outcomes.
How can we make a small difference using the IVUS guidance in real practice?
Usefulness of IVUS study
We can make a small difference

- Treat or not treat
  (Intermediate lesion evaluation, Ostial lesion assessment, LM bifurcation PCI)
- Measurement of MLA, lesion length, reference VD, degree of remodeling
- Plaque characterization
- Procedure Optimization
Treat or not Treat
Big discrepancy!

EEM : 14.04 mm²
Lumen : 3.2 mm²
Area stenosis : 71.5%
Treat or not Treat

2 stent or 1 stent?
IVUS evaluation before stenting showed Minimal-disease on the LCX OS…

LAD Ostium

LCX Ostium
Single Stenting Cross-Over with minimal-disease at LCX OS

Cypher 3.5 × 23 mm

Additional high pressure Inflation with 4.0 mm Non-compliant balloon
Single Stenting Cross-Over
with minimal-disease at LCX OS

Perfect Result!
I can avoid two stents technique under the IVUS guidance.

I can make a small difference !!
TLR at 4 year

Data from MAIN COMPARE Registry
Usefulness of IVUS study
We can make a small difference

- Treat or not treat
  (Intermediate lesion evaluation, Ostial lesion assessment, LM bifurcation PCI)
- Measurement of MLA, lesion length, reference VD, degree of remodeling
- Plaque characterization
- Procedure Optimization
Real estimation of the reference vessel diameter, MLA, lesion length and degree of remodeling are important to choose appropriate stent size.
Left Main disease
MLA < 6.0 mm²

Prediction of FFR (0.75) with IVUS parameter

### Epicardial Artery Disease

**MLA < 4.0 mm²**

<table>
<thead>
<tr>
<th></th>
<th>IVUS MLA ≥4.0mm²</th>
<th>IVUS MLA &lt;4.0mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFR &lt; 2.0</td>
<td>2</td>
<td>27</td>
</tr>
<tr>
<td>CFR ≥ 2.0</td>
<td>39</td>
<td>4</td>
</tr>
<tr>
<td>+ Spect</td>
<td>4</td>
<td>42</td>
</tr>
<tr>
<td>- Spect</td>
<td>20</td>
<td>1</td>
</tr>
</tbody>
</table>

Diagnostic accuracy = 92%.
Abizaid et al. Am J Cardiol 1998;82:42-8

Diagnostic accuracy = 93%.

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**FFR < 0.75**

\[ R^2 = 0.618 \]

**IVUS MLA <4.0mm²**
Usefulness of IVUS study
We can make a small difference

- Treat or not treat
  (Intermediate lesion evaluation, Ostial lesion assessment, LM bifurcation PCI)
- Measurement of MLA, lesion length, reference VD, degree of remodeling
- Plaque characterization
Plaque characterization is important.
We need some plaque modification for calcific lesions and some pre-treatment for vulnerable plaque.
Usefulness of IVUS study
We can make a small difference

- Treat or not treat
  (Intermediate lesion evaluation, Ostial lesion assessment, LM bifurcation PCI)
- Measurement of MLA, lesion length, reference VD, degree of remodeling
- Plaque characterization
- Procedure Optimization
IVUS predictors of Angiographic Restenosis

Stent CSA
Total stent length

odds ratio = 0.584, 95% CI 0.385–0.885, p = 0.011

odds ratio = 1.028, 95% CI 1.002–1.055, p = 0.038

Park, DW. AJC 2006;98:353-356, AMC data
Hong MK, Eur Heart J, 2006:27:1305, AMC data
How Long stented Length and How Big stent CSA would be good for the long-term outcomes in real practice?
Epicardial Artery disease
Total stent length < 40 mm

AMC Cypher Registry

Hong MK, Eur Heart J, 2006:27:1305,

Stent length (mm) by IVUS

Specificity
Sensitivity

(%)
Epicardial Artery disease
Stent CSA > 5.5 mm²

AMC Cypher Registry

Hong MK, Eur Heart J, 2006:27:1305
Restenosis Rate according to Stented Length and Stent CSA by IVUS

AMC Cypher Registry

<table>
<thead>
<tr>
<th>Stent length (mm)</th>
<th>Stent area (mm²)</th>
<th>Restenosis Rate</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 40 and ≥ 5.5</td>
<td></td>
<td>1/284 (0.4%)</td>
<td></td>
</tr>
<tr>
<td>≤ 40 or &lt; 5.5</td>
<td></td>
<td>3/127 (2.4%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>&gt; 40 or ≥ 5.5</td>
<td></td>
<td>6/70 (8.6%)</td>
<td></td>
</tr>
<tr>
<td>&gt; 40 &lt; 5.5</td>
<td></td>
<td>11/62 (17.7%)</td>
<td></td>
</tr>
</tbody>
</table>
## Restenosis Rate according to Stented Length by QCA

### AMC Cypher Registry

<table>
<thead>
<tr>
<th>Stented Length</th>
<th>Restenosis (n=20)</th>
<th>No Restenosis (n=257)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stented length ≥ 46 mm</td>
<td>14 (13.5%)</td>
<td>90 (86.5%)</td>
</tr>
<tr>
<td>Stented length &lt; 46 mm</td>
<td>6 (3.5%)</td>
<td>167 (96.5%)</td>
</tr>
</tbody>
</table>

Sensitivity = 70%, Specificity = 65%, Positive predictive value = 14%, Negative predictive value = 97%
IVUS Guidance in Real Practice
(Rule of 5)

*How Big* stent CSA : > 5.5 mm²

*How Long* stented length : <50 mm

< 5% TLR rate
Why IVUS guided?

A small difference made by IVUS guidance can make a big difference in late clinical outcomes – **SURVIVAL BENEFIT!**
Old Issue
but New Insight!
## Epicardial Artery disease
### MLA < 4.0 mm²

<table>
<thead>
<tr>
<th></th>
<th>IVUS MLA ≥4.0mm²</th>
<th>IVUS MLA &lt;4.0mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFR &lt; 2.0</td>
<td>2</td>
<td>27</td>
</tr>
<tr>
<td>CFR ≥ 2.0</td>
<td>39</td>
<td>4</td>
</tr>
</tbody>
</table>

+ Spect

<table>
<thead>
<tr>
<th></th>
<th>IVUS MLA ≥4.0mm²</th>
<th>IVUS MLA &lt;4.0mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Spect</td>
<td>4</td>
<td>42</td>
</tr>
<tr>
<td>- Spect</td>
<td>20</td>
<td>1</td>
</tr>
</tbody>
</table>

*Diagnostic accuracy = 92%.*

*Abizaid et al. Am J Cardiol 1998;82:42-8*

*Diagnostic accuracy = 93%.*

*Nishioka et al. J Am Coll Cardiol 1999;33:1870-8*

---

### FFR < 0.75

\[ R^2 = 0.618 \]

---

*No doubt about it?*

*Takagi, et al. Circulation 1999;100:250-5*
We need re-validation of IVUS MLA for assessment of significant coronary stenosis; Comparison with Stress Myocardial Perfusion Imaging

Comparison study of IVUS and Thallium scan
AMC prospective cohort registry
Preliminary analysis, 2010 TCTAP
Distributions of MLA in all lesions (n=193 lesions, 156 pts)

$P<0.01$

$1.65 \pm 0.6 \text{mm}^2$

$2.32 \pm 1.1 \text{mm}^2$

N=41

N=152
Distributions of MLA in all lesions (n=193 lesions, 156 pts)

- Thallium(+)
  - $N=41$

- Thallium(-)
  - $N=152$
ROC curves for MLA measured by IVUS to discriminate thallium scan (+) and (-)

AUC 0.707 ± 0.041, p<0.01
Plots for the sensitivity & specificity of MLA

Best cut off value: 2.125 mm$^2$

- Sensitivity 87.8%
- Specificity 49.3%
If you compared the baseline IVUS findings, you may understand why previous cut-off values are so big.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>142</td>
<td>53</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>FFR</td>
<td>0.85 ± 0.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MLA, mm²</td>
<td>2.5±1.0</td>
<td>3.9±2.5</td>
<td>3.9±2.0</td>
<td>4.4±2.0</td>
</tr>
<tr>
<td>MVA, mm²</td>
<td>10.9±4.5</td>
<td>12.0±4.6</td>
<td></td>
<td>13.2±4.4</td>
</tr>
<tr>
<td>Area stenosis %</td>
<td>65±16</td>
<td>65±18</td>
<td>55±24</td>
<td>43±24</td>
</tr>
<tr>
<td>Plaque burden %</td>
<td>75±10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut-off of MLA mm²</td>
<td>1.86 (FFR&lt;0.8)</td>
<td>4.0 (FFR&lt;0.75)</td>
<td>3.0 (FFR&lt;0.75)</td>
<td>4.0 (CFR&lt;2.0)</td>
</tr>
</tbody>
</table>
Can MLA measured by IVUS be used as a surrogate for clinical ischemia defined with FFR <0.8?

Comparison study of FFR, IVUS, TMT, and Thallium scan
AMC prospective cohort registry
Preliminary analysis, 2010 TCTAP
# Intermediate Lesions

**N=142**

<table>
<thead>
<tr>
<th></th>
<th>Mean±SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FFR, baseline</strong></td>
<td>0.95 ± 0.65</td>
<td>0.4 - 1.0</td>
</tr>
<tr>
<td><strong>FFR, adenosine</strong></td>
<td>0.85 ± 0.89</td>
<td>0.4 - 1.0</td>
</tr>
<tr>
<td><strong>MLA, mm²</strong></td>
<td>2.54 ± 1.01</td>
<td>0.8 - 5.9</td>
</tr>
<tr>
<td><strong>MVA, mm²</strong></td>
<td>10.97 ± 4.00</td>
<td>2.6 - 22.1</td>
</tr>
<tr>
<td><strong>Length of lumen area &lt;3.0 mm², mm</strong></td>
<td>4.89 ± 6.11</td>
<td>0 - 25.9</td>
</tr>
<tr>
<td><strong>Plaque burden,%</strong></td>
<td>75 ± 10</td>
<td>34 - 94</td>
</tr>
</tbody>
</table>

**Vessel**

- **LAD** | 95 (67%)  
- **LCX** | 15 (11%)  
- **RCA** | 32 (22%)  

---

*Cardiovascular Research Foundation*

*UNIVERSITY OF ULSAN COLLEGE OF MEDICINE*  
*ASAN Medical Center*
Can MLA cut-off value by IVUS predict FFR <0.8?

**Graph:**
- Scatter plot with IVUS-MLA (mm²) on the x-axis and FFR, Post-Adenosin on the y-axis.
- Correlation coefficient: r = 0.511, p < 0.001.

**Statistics:**
- Sensitivity: 64%
- Specificity: 88%
- PPV: 53%
- NPV: 92%
- AUC: 0.798
- MLA = 1.63 mm²

Confidence Interval: (95% CI = 0.722 - 0.861)
Functional PCI

Treat or Not treat:
- FFR guided – Decision making

How to treat:
- IVUS guided – Optimizing procedure

Do we have to choose only one?

At this stage, these two are complementary for good clinical outcomes.
Coronary Intervention;
Future Perspective

Functional PCI

FFR guided - Decision making
IVUS guided - Optimizing procedure

You Can Save Lives!!
Thank You !!

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