Optical Coherence Tomography (OCT) What do you need to see

Ramesh Daggubati, MD FACC FSCAI
Associate Chief of Cardiology
Director of Interventional Cardiology
NYU Winthrop Hospital, Mineola, NY

Tools in the Cath Lab: Physiology, Anatomy, and Biology

- FEA
- CFR
- FFR
- IVUS
- Endothel. Fx
- Vasospasm
- WSS
- NIR
- OCT
- VH IVUS
Optical Coherence Tomography

Optical coherence tomography (OCT) is an optical imaging modality that uses near-infrared light reflectance to produce high-resolution in vivo images of vessel anatomy, tissue microstructure and stents.

Key Features:
- Uses light, instead of ultrasound
- 10x higher resolution than IVUS
- Fast image acquisition – 20x faster than IVUS
- Images acquired are sharp, detailed and easier to interpret

Images: Drs. Grube, Buellesfeld, Guerkens and Mueller, Helios Heart Center, Siegburg, Germany
Intravascular Imaging for PCI Guidance and Optimization in 2018...

Stent Deployment and PCI Optimization

Guiding PCI in Stent Failure (Restenosis, Thrombosis, and Neoatherosclerosis)

Lesion Morphology in ACS

Relationship between IVUS Use and Definite/Probable Stent Thrombosis within 1 year

HR: 0.50 [95% CI: 0.29, 0.86]  
P = 0.01

0.52% 1.04%

Number at risk:  
IVUS Use 3349 3251 3221 3197 3023  
No IVUS Use 5234 5015 4978 4938 4585

Witzenbichler B et al. Circulation 2014;129:463-70
**Relationship between IVUS Use and MI within 1 year**

<table>
<thead>
<tr>
<th>Time in Months</th>
<th>MI (%)</th>
<th>IVUS Use</th>
<th>No IVUS Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.0</td>
<td>2.5%</td>
<td>3.7%</td>
</tr>
<tr>
<td>3</td>
<td>1.8</td>
<td>2.7%</td>
<td>3.6%</td>
</tr>
<tr>
<td>6</td>
<td>2.5</td>
<td>2.9%</td>
<td>3.7%</td>
</tr>
<tr>
<td>9</td>
<td>3.2</td>
<td>3.3%</td>
<td>3.8%</td>
</tr>
<tr>
<td>12</td>
<td>3.9</td>
<td>3.7%</td>
<td>4.0%</td>
</tr>
</tbody>
</table>

Number at risk:
- IVUS Use: 3349, 3259, 3171, 3141, 2969
- No IVUS Use: 5234, 4932, 4882, 4830, 4460

HR: 0.67 [95% CI: 0.51, 0.87]  
P = 0.002

**IVUS vs OCT**

<table>
<thead>
<tr>
<th>Technical Characteristics</th>
<th>IVUS / VH-IVUS</th>
<th>OCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technique</td>
<td>Ultrasound</td>
<td>Optic: near-infrared light</td>
</tr>
<tr>
<td>Axial Resolution</td>
<td>100-200 μm</td>
<td>10-20 μm</td>
</tr>
<tr>
<td>Lateral Resolution</td>
<td>200-300 μm</td>
<td>20-100 μm</td>
</tr>
<tr>
<td>Penetration Depth</td>
<td>4-8 mm</td>
<td>1-1.5 mm</td>
</tr>
<tr>
<td>Acquisition Rate / Frame Rate</td>
<td>30 frames/sec</td>
<td>100 frames/sec*</td>
</tr>
<tr>
<td>Auto-pullback Speed</td>
<td>1-3 mm/sec</td>
<td>20 mm/sec*</td>
</tr>
</tbody>
</table>
ILUMIEN II

Stone G et al. TCT 2014

ILUMIEN III- Optimize PCI

N=420 pts undergoing PCI, multicenter Study
Primary Efficacy Endpoint (powered)
• Post-PCI MSA assessed by OCT in each randomized arm, measured at the independent OCT core laboratory blinded to imaging modality assignment. Testing will be done in a hierarchical manner as follows:
  1. Non-inferiority of OCT guided stenting to IVUS guided stenting
  2. Superiority of OCT guided stenting to Angiography guided stenting
  3. Superiority of OCT guided stenting to IVUS guided stenting

Primary Safety Endpoint (non-powered)
• Procedural MACE defined as procedural complications (angiographic dissection, perforation, thrombus, and acute closure) requiring active interventions (prolonged balloon inflations, additional stent implantation, or pericardiocentesis)

Primary Endpoint
Final post-PCI MSA by OCT

OCT 5.79 mm² [4.54, 7.34]
IVUS 5.89 mm² [4.67, 7.80]

97.5% one-sided CI: [-0.70, -]

P_{noninferiority} = 0.001

OCT larger
IVUS larger
NI margin

0.0
-1.0 mm²
**Secondary Endpoints**

<table>
<thead>
<tr>
<th></th>
<th>OCT (n=140)</th>
<th>IVUS (n=135)</th>
<th>Angio (n=140)</th>
<th>P (\text{OCT vs IVUS})</th>
<th>P (\text{OCT vs Angio})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal stent area, mm(^2)</td>
<td>5.79 [4.54, 7.34]</td>
<td>5.89 [4.67, 7.80]</td>
<td>5.49 [4.39, 6.59]</td>
<td>0.42</td>
<td>0.12</td>
</tr>
<tr>
<td>Min stent expansion, %</td>
<td>88 ± 17</td>
<td>87 ± 16</td>
<td>83 ± 13</td>
<td>0.77</td>
<td>0.02</td>
</tr>
<tr>
<td>Mean stent expansion, %</td>
<td>106 [98, 120]</td>
<td>106 [97, 117]</td>
<td>101 [92, 110]</td>
<td>0.63</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>Expansion</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Optimal (&gt;95%)</td>
<td>26%</td>
<td>25%</td>
<td>17%</td>
<td>0.84</td>
<td>0.07</td>
</tr>
<tr>
<td>- Acceptable (90 - &lt;95%)</td>
<td>16%</td>
<td>12%</td>
<td>3.7%</td>
<td>0.42</td>
<td>0.0008</td>
</tr>
<tr>
<td>- Unacceptable (&lt;90%)</td>
<td>59%</td>
<td>63%</td>
<td>79%</td>
<td>0.45</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

**Dissections**

<table>
<thead>
<tr>
<th></th>
<th>OCT (n=140)</th>
<th>IVUS (n=135)</th>
<th>Angio (n=140)</th>
<th>P (\text{OCT vs IVUS})</th>
<th>P (\text{OCT vs Angio})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissection, any</td>
<td>28%</td>
<td>40%</td>
<td>44%</td>
<td>0.04</td>
<td>0.006</td>
</tr>
<tr>
<td>Major</td>
<td>14%</td>
<td>26%</td>
<td>19%</td>
<td>0.009</td>
<td>0.25</td>
</tr>
<tr>
<td>Minor</td>
<td>14%</td>
<td>13%</td>
<td>25%</td>
<td>0.84</td>
<td>0.02</td>
</tr>
</tbody>
</table>

**Major Dissection**

1) Angle >60°
2) Length >3 mm
Dissection Detection in the IVUS arm: OCT vs. IVUS

<table>
<thead>
<tr>
<th></th>
<th>IVUS (n=140)</th>
<th>OCT (n=135)</th>
<th>P OCT vs. IVUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissection, any</td>
<td>16%</td>
<td>40%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Major</td>
<td>11%</td>
<td>26%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Minor</td>
<td>5.1%</td>
<td>13%</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Malapposition

<table>
<thead>
<tr>
<th></th>
<th>OCT (n=140)</th>
<th>IVUS (n=135)</th>
<th>Angio (n=140)</th>
<th>P OCT vs IVUS</th>
<th>P OCT vs Angio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malapposition, any</td>
<td>41%</td>
<td>38%</td>
<td>59%</td>
<td>0.62</td>
<td>0.002</td>
</tr>
<tr>
<td>Major</td>
<td>11%</td>
<td>21%</td>
<td>31%</td>
<td>0.02</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Minor</td>
<td>31%</td>
<td>18%</td>
<td>28%</td>
<td>0.01</td>
<td>0.60</td>
</tr>
</tbody>
</table>

Major

Strut(s) >0.2 mm from vessel edge and stent underexpansion
Malapposition Detection in the IVUS arm: OCT vs. IVUS

<table>
<thead>
<tr>
<th></th>
<th>IVUS (n=140)</th>
<th>OCT (n=135)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malapposition, any</td>
<td>19%</td>
<td>39%</td>
<td>0.0002</td>
</tr>
<tr>
<td>Major</td>
<td>14%</td>
<td>21%</td>
<td>0.06</td>
</tr>
<tr>
<td>Minor</td>
<td>5.0%</td>
<td>18%</td>
<td>0.003</td>
</tr>
</tbody>
</table>

OCT 3D reconstruction

- tissue prolapse
- distal
- proximal
- Side branch

Volume rendering

Film No: 091354
Position of MLA in relation to Plaque Rupture

...not necessarily coincident: prox or distal

Plaque Rupture
MLA site
Proximal Reference

Courtesy of Dr. Giulio Guagliumi

Qualitative Lesion Assessment
Plaque Morphology Assessment

Fibrous    Lipid-Rich    Calcium
Quantitative Lesion Assessment


Stent Apposition Assessment: OCT vs. IVUS

Stent Apposition Assessment


Stent Expansion: Stent Area Measurements

Dissection Assessment: OCT vs. IVUS

In-Stent Restenosis (ISR)
Late Stent Thrombosis

Bad surprise on OCT

Stent crushed against the vessel wall
Conclusions

• OCT-guided PCI using a specific EEL-based stent optimization strategy was non-inferior to IVUS-guided PCI for achieving MSA.

• OCT-guided PCI resulted in superior stent expansion and procedural success compared to angiography-guided PCI.

• OCT-guided PCI resulted in the fewest untreated major dissections and areas of major stent malapposition.

Thank you
• Female, 72 years old,
• Admission: effort / rest angina,

Intermediate 60% narrowing in the prox LAD
MLA=1,87 mmq

FD-OCT

Significant narrowing with 1.8 mm² MLA at OCT
MLA=1,87 mmq
PTCA done with DES 2,5x28mm

POT on prox LAD (after LAD-Diag rewiring)

Apparently good result
Bad surprise on OCT

Stent crushed against the vessel wall

How to fix it?

Strategy: Opening of Diagonal ostium with POBA followed by DES deployment (2.5 x 23mm).
DES (2.5 x 23mm), positioning in the LAD-Diagonal

Kissing balloon

Final angio

Bifurcation LAD/Diag

Final OCT
distal→prox

LAD ostium