ANGIOPLASTY SUMMIT – TCTAP 2010
Imaging Workshop

OCT Findings: Lesson from Stable vs Unstable Plaques

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DISCLOSURE OF FINANCIAL INTERESTS

Consultant
Boston Scientific
Volcano

Grant/ Research Support
Medtronic
Boston Scientific
LightLab Imaging
Abbott Vascular
Labcoat

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Calcified Artery with/without Surface Lipid Pool

OFDI  IVUS
From a Foggy Sight to a Clear Vision
ACS: Focus on mid-distal LAD

V. Sirbu  Ospedali Riuniti di Bergamo
CSA = 6.17 mm$^2$

CSA stenosis = 31%

CSA = 5.10 mm$^2$

CSA = 8.70 mm$^2$
TCFA in Proximal LAD
Thin-cap fibroatheroma (TCFA)

- TCFA was defined as a plaque with fibrous cap <65µm thick.
- The high resolution of OCT has an ability to identify thin-fibrous cap clearly even if it is less than 100µm.
Clinical Presentation and Plaque Morphology in Unstable Angina

M. Mizukoshi et al. i2 ACC. 2010; JACC Poster 1152-257
Multivessel Disease: SAP vs AMI

Infarct Related Artery

Plaque rupture

Multivessel Disease: SAP vs AMI
Non Infarct Related Artery

The culprit lesion was in LCX (#11). TCFA (⑥), plaque rupture (⑦, ⑧) and intracoronary thrombus (⑦, ⑧) were observed by OCT. Although the plaques in LAD (⑫, ⑬) were not unstable, TCFA (①-⑤) and plaque rupture (③, ④, ⑤, ⑩, ⑪) were detected by OCT in the non-culprit lesions of RCA and LCX.
ACS Multilink™3.0/25 mm

12 yrs after implant

G. Guagliumi, V. Sirbu    Ospedali Riuniti di Bergamo
LAD distally to the thrombotic stent site in VLST of BMS

Ospedali Riuniti di Bergamo
TCFA rupture

Ospedali Riuniti di Bergamo
TCFA rupture

Ospedali Riuniti di Bergamo
Use of VH-IVUS vs OCT for detecting *in-vivo* TCFA

**Non-thin-cap IVUS-derived TCFA  n=33**

- % necrotic-core: 15%
- Angle of the total NCCL 35.8°
- Cap thickness: 90µm

**Definite TCFA  n= 28**

- % necrotic-core: 22%
- Angle of the total NCCL 100.3°
- Cap thickness: 40µm

*T. Sawada, et al. EHJ 2008; 29(9):1136-1146*
## Combined use of IVUS-VH and OCT for detection of TCFA

|                      | Non-TCFA VH +, OCT -  
|----------------------|-------------------------|-------------------------|-------------------------|
|                      | (n=33)                  | Definite-TCFA VH +, OCT +  
|                      |                         | (n=28)                  |                         |
| **P**                |                         |                         |                         |
| **Gray-scale IVUS**  |                         |                         |                         |
| Plaque volume (mm$^3$/cm) | 65.3 (39.3, 91.4) | 96.3 (75.6, 117.0) | 0.001 |
| Remodelling index    | 1.10 (1.06, 1.13)       | 1.21 (1.17, 1.25)       | 0.0005                     |
| **VH**               |                         |                         |                         |
| % Necrotic-core      | 18.6 (15.7, 21.4)       | 20.0 (17.0, 22.9)       | NS                        |
| Total NCCL angle (degree) | 54.6 (35.6, 73.5) | 89.4 (63.6, 112.4) | 0.0003                    |

*T. Sawada, et al. EHJ 2008; 29(9):1136-1146*
in-vivo Association between Positive Remodeling and TFCA

IVUS and OCT imaging in 54 lesions from 48 pts

% of TCFA within each group

- Positive
- Absent
- Negative

\[ p < 0.001 \]

O. Raffael Eur Heart J 2008; 29:1721
OCT identifies plaque rupture, cap erosion and TCFA...and Thrombus

OCT vs AS vs IVUS: 30 AMI pts

<table>
<thead>
<tr>
<th>Finding</th>
<th>OCT (n=30)</th>
<th>AS (n=30)</th>
<th>IVUS (n=30)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibrous cap disruption</td>
<td>73%* †</td>
<td>47%</td>
<td>40%</td>
<td>0.021</td>
</tr>
<tr>
<td>Fibrous cap erosion</td>
<td>23%* †</td>
<td>3%</td>
<td>0%</td>
<td>0.003</td>
</tr>
<tr>
<td>Thrombus</td>
<td>100% †</td>
<td>100% ‡</td>
<td>33%</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

* OCT vs AS, p<0.05. † OCT vs IVUS, p<0.01. ‡ AS vs IVUS, p<0.01.

<table>
<thead>
<tr>
<th>OCT Findings of Culprit Lesions</th>
<th>STEMI n=40</th>
<th>NSTE ACS n=49</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plaque Rupture %</td>
<td>70</td>
<td>47</td>
<td>0.033</td>
</tr>
<tr>
<td>Lipid Rich Plaque %</td>
<td>90</td>
<td>71</td>
<td>0.036</td>
</tr>
<tr>
<td>(&gt;= 2 Quadrants)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TFCA %</td>
<td>78</td>
<td>49</td>
<td>0.008</td>
</tr>
<tr>
<td>Fibrous Cap Thickness µm</td>
<td>55±20</td>
<td>109±55</td>
<td>0.0001</td>
</tr>
<tr>
<td>Thrombus %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td>78</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>22</td>
<td>41</td>
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<tr>
<td>None</td>
<td>0</td>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>

M. Riga i2ACC 2010, JACC A190 : 2501-503
**OCT and IVUS Findings After PCI in UAP and SAP Patients**

- **Inadequate Stent Apposition**
  - **IVUS**: Inadequate
  - **OCT**: Inadequate
  - **p = 0.001**

- **Tissue Protrusion**
  - **IVUS**: Tissue
  - **OCT**: Tissue

- **Intracoronary Thrombus**
  - **IVUS**: Intracoronary
  - **OCT**: Intracoronary
  - **P < 0.001**

**OCT vs IVUS**

*T. Kubo et al J Am Coll Cardiovasc Imaging, July 2008:475-84*
HORIZONS AMI: 2 Separated Lesions  

TAXUS 2.75 20 mm + 3.0 20 mm

Index Procedure  

13 month FU

Ospedali Riuniti di Bergamo
HORIZONS OCT

13 mos FU

G. Guagliumi MD, Ospedali Riuniti di Bergamo
Difference in DES Incomplete Strut Apposition (ISA)

Stable /UA vs STEMI

Median follow-up time 9 months (range 7 to 72)
DES: Cypher, Taxus, Xience, Biolimus

Thrombus Naturally or Pharmacologically Remodels Overtime

Delayed Healing? Late Incomplete Apposition?
STEMI

Postimplant

6 mos FU

G. Guagliumi, V. Sirbu  Ospedali Riuniti di Bergamo
OCTAMI Trial: Index  RCA  Endeavor 3.0/24 mm

6 mos FU OCT

G. Guagliumi et al TCT Featured Clinical Research,  JACC Intv 2010 May, in press
Coverage distribution in different cross-sections along the Stent 6-month FU
HORIZONS OCT: 13 Months

118 Consecutive STEMI pts enrolled in HORIZONS, 155 Taxus™ vs 45 BMS

Independent Core Labs Blind to the stent assignment
OCT Core Lab: Case Western Reserve University, Cleveland, OH

7,748 cross-sections - 44, 121 struts

Express BMS

Uncovered: 1.10 ± 2.50
Malapposed: 0.07 ± 0.21

Taxus DES

Uncovered: 5.68 ± 6.96
Malapposed: 0.90 ± 2.08

G. Guagliumi et al, LBT Abstracts Circulation 2008;118:2309-17, submitted
Lesion with at least one uncovered strut
Frames with at least one uncovered strut
Uncovered struts

Median follow-up time 9 months (range 7 to 72)

STEMI: N=16
Stable/Unstable Angina: N=27

\( p = 0.04 \)

Consistent Strut Level Analysis among the OCT studies with PES
HORIZONS OCT (AMI), ODESSA (Long Lesions with stent in overlap), OCTDESI (on label)

<table>
<thead>
<tr>
<th>Trial</th>
<th>Taxus</th>
<th>Stents n</th>
<th>Struts n</th>
<th>FU mos</th>
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<tbody>
<tr>
<td>ODESSA</td>
<td>Liberté</td>
<td>44</td>
<td>11,908</td>
<td>6</td>
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<tr>
<td>Horizons OCT</td>
<td>Express</td>
<td>115</td>
<td>34,142</td>
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<tr>
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<td>Liberté</td>
<td>19</td>
<td>34,474*</td>
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</table>

*based on every frame analysis

80,524
Backscattered power curves for calcific, fibrous and lipid tissues

Quantitative Analysis

<table>
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<tr>
<th>Plaque type</th>
<th>Backscattering coefficient</th>
<th>Attenuation coefficient</th>
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<tbody>
<tr>
<td>Calcification</td>
<td>4.9 ± 1.5</td>
<td>5.7 ± 1.4</td>
</tr>
<tr>
<td>Fiber</td>
<td>19.2 ± 5.2</td>
<td>6.6 ± 0.7</td>
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<tr>
<td>Lipid</td>
<td>29.7 ± 6.4</td>
<td>14.9 ± 2.5</td>
</tr>
</tbody>
</table>

OFDI Instent restenosis

Courtesy R. Virmani MD

A. Tanaka, G. Tearney, B. Bouma J Biomed Optics Jan/Feb 2010
Plaque Characterisation

Stents
Conclusions

• Today, the in vivo assessment of entire segments of coronary arteries is possible due to significant improvements in imaging acquisition methods (FD-OCT).

• OCT lesion findings are related to clinical presentation (SAP ≠ ACS, STEMI ≠ nonSTEMI) and different in culprit compared with not culprit vessel.

• Simultaneous assessment of culprit and not culprit lesions can track atherosclerotic changes overtime (Δ cap thickness, Δ number of TFCA,...) evaluating progression and regression and the effects of treatment.

• Challenging informations like macrophage density need to be further validated.

• Incomplete struts apposition, plaque protrusion and thrombus formation after stenting are more frequently observed in UAP vs SAP.

• Data from randomized OCT based studies do not entirely support > uncovered struts in STEMI vs SAP/UAP when treated with PES.

• The major expected advances in OCT for lesion assessment are at 3 different levels: cellular (texture parameters), plaque (tissue characterization spectroscopy) and vessel (3D volumetric rendering of the pathology).
# OCT in Late and Very Late Stent Thrombosis

<table>
<thead>
<tr>
<th>Case</th>
<th>TIME to LST</th>
<th>DES type</th>
<th>Indication at index</th>
<th>Overlap</th>
<th>DES Length, mm</th>
<th>Antiplatelet therapy</th>
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<td>1</td>
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<td>PES</td>
<td>ACS</td>
<td>NO</td>
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</tr>
</tbody>
</table>

Mean 579 days, (424-1100)  
88%  
36±19 mm
Baseline

Prox end

15 mos

Prox end

Distal end

Courtesy G. Tearney  MGH and B. Bouma  MIT  Boston