When and How to use OCT in daily practice

Novas Fronteiras em Cardiologia
Ericeira, February 2014

Francesco Prati
San Giovanni Hospital, Rome
Rome Heart Research
• Coronary lesion assessment with OCT
IVUS

MLA 2.8 mm²
70 Y female with stable angina

Gonzalo et al JACC 2012. The new OCT cut-off is 1.8 mm²
• Identification of culprit lesions in patients with ACS
OCT details plaque morphology with high accuracy

Example of plaque rupture with thrombus in a pt with STEMI

Cons. DOC on OCT JACC 2011
• 61 years old male without a previous history of CAD
• RF: Smoke
• Unstable angina with a single rest episode.
• The ECG showed a transient ST elevation in the anterior leads lasting 5-10 minutes.
FD-OCT: Ruptured plaque with mild thrombus

PTCA done

• Pre-stenting assessment
Acute coronary syndromes
Rupture of an Eccentric ID TCFA and the Thrombotic Tails

Fall Out of the problem Layers of distal Thrombotic Tail (Red cell rich)

Site of min LD
(Angiographic culprit)
(Ruptured TCFA – true culprit?)

Site of the problem Plaque rupture and layers of healed plaque ruptures

R Virmani, CVPath and P Margolis, Volcano Corp
landing of proximal stent edges on lipid pools was significantly more frequent in patients with post procedural MI than in controls (10 [66%] vs 2 [13%], p [ 0.009)
Prediction of No-Reflow

Goldstein et al, JACC Imaging 2010
After DES Stenting (Xience 3.0 x 15 mm)
Missed plaque rupture
Stenting guidance
Example of Pre-intervention IVUS use

1. Some calcifications
2. Clear assessment of plaque burden
3. Measurement of lesion length

**Strategy:** Deployment of 2 DES (28 mm each) avoiding overlapping
Use of FD-OCT to measure lumen areas at the lesion site and references

Mean Diam 2.6 mm
MLA 5.3 mm²

Mean Diam 3.0 mm
MLA 2.6 mm²

Mean Diam 3.0 mm
MLA 7.0 mm²

Mean Diam 5.3 mm
MLA 5.3 mm²
Evidence that I.C. imaging makes the difference
## Meta-analisi
### Restenosi Angiografica Binaria

<table>
<thead>
<tr>
<th>Studio</th>
<th>IVUS-Guidato</th>
<th>Angio-Guidato</th>
<th>Odds Ratios &amp; 95% CI Fixed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RCT’s</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>16/71 (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><strong>Sub-Totale</strong></td>
<td>135/539 (25%)</td>
<td>167/568 (29%)</td>
<td>0,81 [0,62-1,06]</td>
</tr>
<tr>
<td><strong>Registri</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Albiero, 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, 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><strong>Sub-Totale</strong></td>
<td>51/263 (19%)</td>
<td>72/261 (27,5%)</td>
<td>0,63 [0,42-0,95]</td>
</tr>
<tr>
<td><strong>Totale</strong></td>
<td>186/802 (23%)</td>
<td>239/829 (28,8%)</td>
<td>0,75 [0,60-0,94]</td>
</tr>
</tbody>
</table>

X2 Eterogeneità: 0,36
P=0,01

*Casella et al. Eur Heart Journal 2002. Abstract*
• 884 patients undergoing IVUS-guided intracoronary DES implantation
• Propensity-score matched population undergoing DES implantation with angiographic guidance alone

<table>
<thead>
<tr>
<th>1 year outcome</th>
<th>IVUS</th>
<th>No IVUS</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>MACE</td>
<td>14.5</td>
<td>16.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Death</td>
<td>5.77</td>
<td>7.1</td>
<td>0.24</td>
</tr>
<tr>
<td>TLR</td>
<td>5.1</td>
<td>7.2</td>
<td>0.07</td>
</tr>
<tr>
<td>Probable Stent Thrombosis</td>
<td>4.0</td>
<td>5.8</td>
<td>0.08</td>
</tr>
<tr>
<td>Definite Stent Thrombosis</td>
<td>0.7</td>
<td>2.0</td>
<td>0.014</td>
</tr>
</tbody>
</table>

Roy et al Eur Heart J 2008
Clinical Outcome of OCT vs Angiography Alone: the CLI-OPCI Study

F Prati et al.

Eurointervention 2012

Rome Heart Research
Angiography alone versus angiography plus optical coherence tomography to guide decision making during percutaneous coronary intervention: the CLI-OPTI study

Francesco Prati, MD, Luca Di Vito, MD, Giuseppe Biondi-Zoccai, MD, Michele Occhipinti, MD, Alessio La Manna MD, Francesco Burzotta, MD, Vito Ramazzotti, MD, Carlo Trani MD, Laura Materia, PharmD, Corrado Tamburino MD, Italo Porto MD, Alberto Cremonesi MD.

- Department of Interventional Cardiology, San Giovanni- Hospital, Rome, Italy (FP, VR, FI, AM, IP); Centro per la Lotta contro l’Infarto – Fondazione Onlus, Rome, Italy (FP, LDV, GBZ, MO, LM,); Division of Cardiology, University of Catania, Catania, Italy (MO, ALM, CTA); Institute of Cardiology, Catholic University, Rome, Italy (FB, C TR, ); Sansavini Foundation, Cotignola, Italy (AC)
Methods

- Consecutive patients undergoing PCI with angiographic plus OCT guidance (OCT group) at three high OCT-volume Italian centers between 2009 and 2011 were included.
- Patients in the OCT group (335 pts) were matched 1:1 with randomly-selected patients undergoing during the same month PCI with angiographic only guidance (Angio group).
- All patients provided written informed consent, and ethical approval was waived given the observational and retrospective design.

*Euro-PCR 2012, Eurointervention 2012*
• OCT was performed after the achievement of an optimal angiographic result
• The following definitions of sub-optimal OCT results were adopted
Definitions of Sub-Optimal results after stenting

Submitted Euro-PCR 2012
Edge dissection. Width > 200 µ

Stent malapposition. Distance > 200 µ

Thrombus. Thickness > 200 µ

Absence of residual stenosis adjacent to stent endings (MLA < 4.0 mm²)

Underexpansion

In-stent MLA ≥ 90% of the average reference lumen area or ≥ 100% of lumen area of the reference segment with the lowest lumen area
End-points

- The primary end-point of the study was the 12-month rate of cardiac death or non-fatal myocardial infarction (MI).
- Additional end-points were short-term rates of death, cardiac death, and non-fatal MI, and 12-month rates of death, cardiac death, non-fatal MI, target lesion repeat revascularization (TLR) and definite stent thrombosis.
- All outcomes were defined in keeping with the Academic Research Consortium recommendations.
## Baseline characteristics

<table>
<thead>
<tr>
<th></th>
<th>Angiographic group (N=335)</th>
<th>Optical coherence tomography group (N=335)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>67.0±11.5</td>
<td>64.8±11.5</td>
<td>0.016</td>
</tr>
<tr>
<td>Female gender</td>
<td>82 (24.5%)</td>
<td>73 (21.8%)</td>
<td>0.409</td>
</tr>
<tr>
<td>Hypertension</td>
<td>244 (73.8%)</td>
<td>253 (75.5%)</td>
<td>0.427</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>97 (29.0%)</td>
<td>81 (24.2%)</td>
<td>0.162</td>
</tr>
<tr>
<td>Current smoking</td>
<td>113 (33.7%)</td>
<td>115 (34.3%)</td>
<td>0.063</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>176 (53.3%)</td>
<td>214 (64.5%)</td>
<td>0.002</td>
</tr>
<tr>
<td>Prior myocardial infarction</td>
<td>72 (21.5%)</td>
<td>76 (22.7%)</td>
<td>0.709</td>
</tr>
<tr>
<td>Prior percutaneous coronary intervention</td>
<td>78 (23.5%)</td>
<td>115 (34.3%)</td>
<td>0.002</td>
</tr>
<tr>
<td>Prior coronary artery bypass grafting</td>
<td>29 (8.7%)</td>
<td>22 (6.6%)</td>
<td>0.308</td>
</tr>
<tr>
<td>Admission diagnosis</td>
<td></td>
<td></td>
<td>0.005</td>
</tr>
<tr>
<td>ST-elevation myocardial infarction</td>
<td>123 (36.7%)</td>
<td>86 (25.7%)</td>
<td></td>
</tr>
<tr>
<td>Non-ST-elevation acute coronary syndrome</td>
<td>85 (25.4%)</td>
<td>112 (33.4%)</td>
<td></td>
</tr>
<tr>
<td>Stable coronary artery disease</td>
<td>127 (37.9%)</td>
<td>137 (40.9%)</td>
<td></td>
</tr>
<tr>
<td>Left ventricular ejection fraction, %</td>
<td>52.8±10.4</td>
<td>53.8±10.2</td>
<td>0.303</td>
</tr>
<tr>
<td>Post-procedural serum creatinine (mg/dL)</td>
<td>1.1±0.4</td>
<td>1.1±0.3</td>
<td>0.954</td>
</tr>
</tbody>
</table>

*Eurointervention 2012*
<table>
<thead>
<tr>
<th></th>
<th>Angiographic guidance group (N=335)</th>
<th>Angiographic plus optical coherence tomography guidance group (N=335)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of diseased vessels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>159 (47.9%)</td>
<td>122 (36.8%)</td>
<td>0.007</td>
</tr>
<tr>
<td>2</td>
<td>108 (32.8%)</td>
<td>144 (43.4%)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>68 (19.3%)</td>
<td>69 (19.6%)</td>
<td></td>
</tr>
<tr>
<td>Left main disease</td>
<td>8 (2.4%)</td>
<td>22 (6.6%)</td>
<td>0.009</td>
</tr>
<tr>
<td>American College of Cardiology/American Heart Association type B2/C lesion</td>
<td>287 (86.7%)</td>
<td>244 (72.8%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PCI on left anterior descending</td>
<td>179 (53.4%)</td>
<td>204 (60.9%)</td>
<td>0.050</td>
</tr>
<tr>
<td>Multivessel PCI</td>
<td>52 (15.5%)</td>
<td>78 (23.3%)</td>
<td>0.011</td>
</tr>
<tr>
<td>Stent length per patient (mm)</td>
<td>26.0±15.6</td>
<td>29.0±16.6</td>
<td>0.024</td>
</tr>
<tr>
<td>Drug-eluting stent usage</td>
<td>146 (43.6%)</td>
<td>212 (63.3%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Stent overlap</td>
<td>25 (7.5%)</td>
<td>49 (14.6%)</td>
<td>0.003</td>
</tr>
<tr>
<td>Maximum balloon diameter (mm)</td>
<td>3.0±0.5</td>
<td>3.1±0.4</td>
<td>0.037</td>
</tr>
<tr>
<td>Maximum dilation pressure (ATM)</td>
<td>16.7±2.5</td>
<td>16.7±2.8</td>
<td>0.823</td>
</tr>
<tr>
<td>Contrast (mL)</td>
<td>220±56</td>
<td>240±74</td>
<td>0.784</td>
</tr>
</tbody>
</table>

Procedural results

Eurointervention 2012
Results

335 pts with OCT guidance

Eurointervention 2012
## Clinical results

<table>
<thead>
<tr>
<th>Event</th>
<th>Angiographic guidance group (N=335)</th>
<th>Angiographic plus optical coherence tomography guidance group (N=335)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In-hospital events</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac death</td>
<td>3 (0.9%)</td>
<td>2 (0.6%)</td>
<td>0.010</td>
</tr>
<tr>
<td>Non-fatal myocardial infarction</td>
<td>22 (6.5%)</td>
<td>13 (3.9%)</td>
<td>0.096</td>
</tr>
<tr>
<td><strong>Events at 1-year follow-up</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Death</td>
<td>23 (6.9%)</td>
<td>11 (3.3%)</td>
<td>0.035</td>
</tr>
<tr>
<td>Cardiac death</td>
<td>15 (4.5%)</td>
<td>4 (1.2%)</td>
<td>0.010</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>29 (8.7%)</td>
<td>18 (5.4%)</td>
<td>0.096</td>
</tr>
<tr>
<td>Target lesion repeat revascularization</td>
<td>11 (3.3%)</td>
<td>11 (3.3%)</td>
<td>1.0</td>
</tr>
<tr>
<td>Definite stent thrombosis</td>
<td>2 (0.6%)</td>
<td>1 (0.3%)</td>
<td>0.624</td>
</tr>
<tr>
<td><strong>Cardiac death or myocardial infarction</strong></td>
<td>43 (13.0%)</td>
<td>22 (6.6%)</td>
<td><strong>0.006</strong></td>
</tr>
<tr>
<td>Cardiac death, myocardial infarction, or repeat revascularization</td>
<td>50 (15.1%)</td>
<td>32 (9.6%)</td>
<td>0.034</td>
</tr>
</tbody>
</table>

*Eurointervention 2012*
Results

- Unadjusted analyses showed that the OCT group had a lower 12-month risk of cardiac death ($p=0.010$), cardiac death or MI ($p=0.006$), and the composite of cardiac death, MI, or repeat revascularization ($p=0.044$).
- Even at extensive multivariable analysis adjusting for baseline and procedural differences, angiographic plus OCT guidance was associated with a lower risk of cardiac death or MI (OR=$0.49$ [0.25-0.96], $p=0.037$).
- Finally, even propensity score-adjusted analysis exploiting bootstrap resampling confirmed the association between OCT and the 12-month rate of cardiac death or non-fatal MI (OR=$0.37$ [0.10-0.90], $p=0.050$).
Mechanism Of Stent Thrombosis (MOST) Study: a prospective multicentre non-randomized registry.

Eurointervention. 2013

<table>
<thead>
<tr>
<th></th>
<th>Thrombus Site</th>
<th>Control</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subacute Stent Thrombosis</td>
<td>Minimum SA (mm²)</td>
<td>2.1 (1.3-4.5)</td>
<td>3.0 (2.4-5.0)</td>
</tr>
<tr>
<td>Late Stent Thrombosis</td>
<td>Minimum SA (mm²)</td>
<td>3.5 (2.4-5.7)</td>
<td>3.6 (2.5-5.7)</td>
</tr>
</tbody>
</table>

**Subacute ST had a significant stent underexpansion while late/very late ST had a greater stent strut malapposition distance**

G Parodi, A La Manna, L Di Vito, M Valgimigli, M Fineschi, B Bellandi, G Niccoli, B Giusti, R Valenti, A Cremonesi, G Biondi-Zoccai, F Prati
Suboptimal stent deployment in presence of sub-acute thrombosis: a comparative FD-OCT study

21 stent cases with subacute thrombosis vs 42 cases from a control group from the RHR database

F Prati, T Kodama, L Di Vito, V Ramazzotti, A Chisari, V Marco, A Cremonesi, G Parodi, M Albertucci, F Alfonso. PCR 2013
Examples of sub-optimal OCT results in pts with Subacute Thrombosis.

From the MOST Registry

STEMI 8 days after DES deployment

Marked proximal stent malapposition
Examples of sub-optimal OCT results in pts with Subacute Thrombosis.
From the MOST Registry

**STEMI four days after DES deployment**

Distal stent dissection

Pt. CA MA

TCT 2011
Incidence of Non Optimal stent deployment in the OCT arm of the CLI-O PCI study. Comparison between the two groups with and without MACE at 1 Year.

A Chisari, F Prati et al. ESC 2013
Incidence of Non Optimal stent deployment in the OCT arm of the CLI-OPCI study.

A Chisari. F Prati et al. ESC 2013
Incidence of Non Optimal stent deployment in the OCT arm of the CLI-OPCI study.

A Chisari. F Prati et al. ESC 2013
Predictors of Cypher Thrombosis @ CRF

Fujii et al. JACC 2005

- 2,575 patients were treated with 4,722 Cypher stents.
- 21 (0.8%) had stent thrombosis of whom 15 had IVUS
- 12/15 SES thrombosis lesions has stent CSA <5.0mm² (vs 13/45 controls)

*Residual edge stenosis = edge lumen CSA <4.0mm² & plaque burden >70%.
## ADAPT-DES

<table>
<thead>
<tr>
<th></th>
<th>Stent Thromb.</th>
<th>NO Stent Thromb.</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reference lumen CSA (mm²)</strong></td>
<td>8.4</td>
<td>8.1</td>
<td>0.78</td>
</tr>
<tr>
<td>Minimum Lumen CSA (mm²)</td>
<td>5.4</td>
<td>5.8</td>
<td>0.82</td>
</tr>
<tr>
<td>- MLA&lt;5mm²</td>
<td>40%</td>
<td>33.7%</td>
<td>0.74</td>
</tr>
<tr>
<td>- MLA&lt;4mm²</td>
<td>20%</td>
<td>15.4%</td>
<td>0.66</td>
</tr>
<tr>
<td><em><em>Stent expansion</em> (%)</em>*</td>
<td>69.9</td>
<td>73.1</td>
<td>0.68</td>
</tr>
<tr>
<td>Plaque burden at prox ref (%)</td>
<td>63.6</td>
<td>48.7</td>
<td>0.022</td>
</tr>
<tr>
<td>Attenuated plaque in prox. site</td>
<td>60%</td>
<td>26.6%</td>
<td>0.027</td>
</tr>
<tr>
<td>Mean stent expansion* (%)</td>
<td>107</td>
<td>88</td>
<td>0.097</td>
</tr>
<tr>
<td><strong>Max tissue protrusion area (mm²)</strong></td>
<td>1.9</td>
<td>0.7</td>
<td>0.016</td>
</tr>
<tr>
<td><strong>Stent malapposition</strong></td>
<td>20%</td>
<td>12.6%</td>
<td>0.36</td>
</tr>
<tr>
<td>Proximal edge dissection</td>
<td>0.0%</td>
<td>3.2%</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Distal edge dissection</strong></td>
<td>25.0%</td>
<td>4.0%</td>
<td>0.039</td>
</tr>
</tbody>
</table>

A Mehara TCT 2012
The CLI-OPCI III. Registry of FD-OCT Guidance for Coronary Intervention

From March 2008 to March 2013

• 1000 Coronary Intervention with FD-OCT final look and at least one year clinical FU

• Data available by March 2014

Rome Heart Research
Dissections on OCT are not all the same

I am glad I used OCT.....
Pt in the OCT arm of the CLI-OPCI study. He had an AMI at 1Y FU
Left main and complex cases

I am glad I used OCT.....
65 – Year-old male

- effort angina and positive stress testing.
Stent Resolute Integrity 3,5 x 22 mm and Kissing dilatation with ball. 3 x15 mm in the LM-LAD and 3 X 12 mm in the LCX
High pressure inflation with a 4,0 x 10 mm ball.
Optimal angiographic result
FD-OCT: marked underexpansion of the stent with a large area of malapposition
The guide–wire made a wrong path to enter the LCx through the stented LM
Additional intra-stent dilatation with a non compliant balloon 4,5 x10 mm and lastly with a compliant one 5 x 12 mm.
Improved OCT result
The novel Optics OCT System (St Jude).
3-D Reconstruction

Easy identification of guide-wire path
Examples of sub-optimal OCT results in pts with Subacute Thrombosis.

From the MOST Registry

STEMI 8 days after DES deployment

Marked proximal stent malapposition
• When angiography leaves doubts

I am glad I used OCT.....
65 Y/o pt with recent effort angina

Ambiguous lesion in the mid LAD
After DES positioning in the mid LAD (Xience 2.75 x 15)

How to treat the prox LAD lesion?  
Is the LM dissected?
OCT Assessment

LM Dissection

LCx Take-off

Ostial LAD: Area 2,90 mm²
DES positioning (Xience) 3.5 mm with final kissing (3.5 x 3.0 mm)
Mild stent malapposition in the LM

LCx Take-off

Ostial LAD: Area 7.90 mm²
Distal lesion in the LM

LA = 7.1 mm²

Diseased LM with eccentric plaque
Large plaque burden !?

Treat also the Left Main
I.C. Imaging for treatment of STEMI
55 Y/O Male with Anterior STEMI

Treatment with Thrombus-aspiration only

LAD Total Occlusion

Mild Residual Stenosis Timi 3 flow

Large MLA at OCT
I Concepts

OCT-Based Diagnosis and Management of STEMI Associated With Intact Fibrous Cap

Francesco Prati, MD, PHD,*† Shiro Uemura, MD, PHD,‡ Geraud Souteyrand, MD, PHD,§
Renu Virmani, MD, Pascal Motreff, MD, PHD,§ Luca Di Vito, MD, PHD,*†
Giuseppe Biondi-Zoccai, MD, PHD,¶ Jonathan Halperin, MD,#
Valentin Fuster, MD, PHD,** Yukio Ozaki, MD, PHD,†† Jagat Narula, MD, PHD#

Rome, Italy; Nara, Toyoake, Japan; Clermont-Ferrand, France; New York, New York;
Gaithersburg, Maryland; and Madrid, Spain

JACC Imaging 2013
FD- OCT imaging after aspiration thrombectomy to identify plaque erosion as the cause in 31 patients presenting with ST-segment elevation myocardial infarction.

40% of patients with subcritically occlusive plaque were treated with dual antiplatelet therapy without percutaneous revascularization (group 1), and the remaining 60% of patients underwent angioplasty and stenting (group 2).

At a median follow-up of 753 days, all patients were asymptomatic, regardless of stent implantation.

JACC Imaging 2013
Conclusions

Use imaging modalities to:

- Avoid useless interventions
- Identify culprit lesions in patients with ACS using FD-OCT to visualize fresh thrombus
- Define plaque anatomy and localize the LP site in the effort of reducing distal embolization
- Improve clinical results after stenting identifying sub-optimal results
- Improve treatment of AMI and possibly avoid stenting