IVUS-OCT βοηθάει μόνο στην κατανόηση της παθοφυσιολογίας – Υπέρ…

Periklis A. Davlouros, Professor of Cardiology
Invasive Cardiology & Congenital Heart Disease
Patras University Hospital
Conflict of Interest...
Ischemia guided PCI…

- In real-world practice, fewer than 50% of pts are evaluated noninvasively for myocardial ischemia before revascularization therapy

Why does the angiogram fail?

Severe narrowings?

Kern JACC 2010;55;173-185
Threshold value of FFR to detect significant stenosis in humans

FFR

1.0  0.80  0.75  0

non-signif.  stenosis significant

FFR is the **only** functional index which has ever been validated versus a **true gold standard**.
*(Prospective multi-testing Bayesian methodology)*

**ALL** studies ever performed in a wide variety of clinical & angiographic conditions, found threshold between 0.75 and 0.80

**Diagnostic accuracy ≥ 93%**

Oldroyd et al, *Circulation* 2010
Advanced Imaging Techniques...

- IVUS
- IVUS-VH
- Angioscopy
- OCT
- NIRS

VH-IVUS: definition of high-risk plaques and necrotic cores by their ultrasound characteristic.

NIRS: detection of lipid-rich plaques by their cholesterol ester composition.
OCT vs. standard imaging

- **OCT**: Unprecedented resolution (10 to 15 μm) among intravascular imaging techniques.
- **Ultrasound**: High frequency, standard clinical.

**Diagram**:
- Resolution (log) vs. Penetration depth (log).
  - OCT circle, Confocal microscopy, Ultrasound.
  - OCT resolution range: 1 μm to 1 mm, Penetration depth: 1 mm to 10 cm.
Pre-procedure Area assessment
IVUS > OCT = real value > QCA
Technical considerations: QCA/IVUS/OCT
Accurately size the vessel

**Sizing Variability:**
- Sizing accuracy can vary by 0.3 mm depending on imaging modality used
- Recognize the risk of under/over-estimating vessel size by visual estimation

![Diagram showing actual size, OCT, IVUS, QCA, and visual estimate with margins of error and variability]

Intracoronary imaging (IVUS) has a **poor correlation** with physiological testing for identification of ischemia inducing lesions…
Diagnostic Accuracy of Intravascular Ultrasound-Derived Minimal Lumen Area Compared With Fractional Flow Reserve—Meta-Analysis
Pooled Accuracy of IVUS Luminal Area Versus FFR

Bruno R. Nascimento,1,2,3 MD, MSc, Marcos R. de Sousa,1 MD, MSc, PhD, Bon-Kwon Koo,4 MD, PhD, Habib Samady,5 MD, Hiram G. Bezerra,6 MD, PhD, Antonio L.P. Ribeiro,1,2 MD, PhD, and Marco A. Costa,6* MD, PhD, FACC, FSCAI

Catheterization and Cardiovascular Interventions 84:377-385 (2014)
Outcomes of PCI in Intermediate CAD: FFR–Guided Vs. IVUS–Guided…

IVUS-guided lesion selection resulted in almost 3 times as many treated lesions without any difference in the event rate…
Q: Why can we **not** use IVUS/OCT for functional assessment?

A: A single cross-sectional area does not mean the same thing everywhere.
IVUS cutoff is affected by size of vessel

**4 mm² TOO SMALL?**

- CSA: 4 mm²
- 55% stenosis
- FFR = 0.60

**4 mm² SUFFICIENT?**

- CSA: 4 mm²
- 10% stenosis
- FFR = 0.90
Small Caliper Vessels…

- Lesions in small-caliber vessels prove especially difficult for IVUS evaluation (no cut-off)...

- FFR-positive lesions are a minority in small vessels (35-40% in 3 studies)
  - Given the higher rates of restenosis in small vessels even with DES, these studies strongly support FFR-selected PCI in small coronaries…
Can MLA Predict the Functional Significance of Coronary Artery Stenosis?

<table>
<thead>
<tr>
<th>IVUS–Measured MLA Criteria for Functionally Significant Lesions</th>
<th>Nishioka et al(^{39})</th>
<th>Briguori et al(^{40})</th>
<th>Takagi et al(^{41})</th>
<th>Abizaid et al(^{42})</th>
<th>Jasti et al(^{43})</th>
<th>Lee et al(^{44})</th>
<th>Kang et al(^{45})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional study</td>
<td>Thallium (+)</td>
<td>FFR &lt;0.75</td>
<td>FFR &lt;0.75</td>
<td>CFR ≥2.0</td>
<td>FFR 0.75</td>
<td>FFR &lt;0.75</td>
<td>FFR &lt;0.8</td>
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<tr>
<td>No. of lesions</td>
<td>70</td>
<td>53</td>
<td>51</td>
<td>112</td>
<td>55</td>
<td>94</td>
<td>201</td>
</tr>
<tr>
<td>Cutoff MLA, mm(^2)</td>
<td>≤4.0</td>
<td>≤4.0</td>
<td>&lt;3.0</td>
<td>≥4.0</td>
<td>5.9(^*)</td>
<td>≤2.0(^†)</td>
<td>&lt;2.4</td>
</tr>
<tr>
<td>Accuracy, %</td>
<td>NA</td>
<td>79</td>
<td>90.2</td>
<td>89</td>
<td>94</td>
<td>NA</td>
<td>68</td>
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<tr>
<td>Sensitivity, %</td>
<td>90</td>
<td>92</td>
<td>83.0</td>
<td>NA</td>
<td>93</td>
<td>82.4</td>
<td>90</td>
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<tr>
<td>Specificity, %</td>
<td>88</td>
<td>56</td>
<td>92.3</td>
<td>NA</td>
<td>95</td>
<td>80.8</td>
<td>60</td>
</tr>
</tbody>
</table>

\(^*\) For left main coronary arteries.

\(^†\) For small-vessel disease (<3 mm).
Scatterplot showing the relationship between intravascular ultrasound–determined minimal lumen area (MLA) and fractional flow reserve (FFR).

96% NPV for an MLA ≥ 2.4 mm²
The coin toss experiment: implications for risk stratification

- 96% NPV for an MLA \( \geq 2.4 \text{ mm}^2 \) …
- NPV depends on the pretest probability (21%)
- An IVUS parameter with no predictive power (AUC = 0.5, equivalent to a coin toss) would have NPV 79%…
  - This comparison makes the reported NPV of 96% for MLA \( \geq 2.4 \text{ mm}^2 \) to seem appropriately less dramatic…

So when should we use IVUS?

Once an ischemia-producing lesion has been identified:

- To determine lesion length, vessel size, plaque composition, relationship to bifurcation

<table>
<thead>
<tr>
<th>Plaque Type</th>
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<tr>
<th>Lesion / Vessel Size</th>
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<thead>
<tr>
<th>Lesion Length</th>
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<tr>
<th>Stent Optimization</th>
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IVUS guidance saves lives in LM PCI

Impact of Intravascular Ultrasound Guidance on Long-Term Mortality in Stenting for Unprotected Left Main Coronary Artery Stenosis

Seung-Jung Park, MD, PhD*; Young-Hak Kim, MD, PhD*; Duk-Woo Park, MD, PhD; Seung-Whan Lee, MD, PhD; Won-Jang Kim, MD, PhD; Jon Suh, MD; Sung-Cheol Yun, PhD; Cheol Whan Lee, MD, PhD; Myeong-Ki Hong, MD, PhD; Jae-Hwan Lee, MD, PhD; Seong-Wook Park, MD, PhD; for the MAIN-COMPARE Investigators

\[\text{Conclusions} - \text{Elective stenting with IVUS guidance, especially in the placement of drug-eluting stent, may reduce the long-term mortality rate for unprotected left main coronary artery stenosis when compared with conventional angiography guidance.} \ (\text{Circ Cardiovasc Intervent. 2009;2:167-177.})\]
While IVUS is the most used intravascular imaging modality in interventional cardiology, it is used in < 20% of cases...
First-in-man evaluation of intravascular optical frequency
domain imaging (OFDI) of Terumo: a comparison with
intravascular ultrasound and quantitative coronary angiography

Takayuki Okamura¹, MD, PhD; Yoshinobu Onuma¹, MD; Héctor M. García-García², MD, PhD;
Robert-Jan M van Geuns¹, MD, PhD; Joanna J. Wykrzykowska¹, MD; Carl Schultz¹, MD, PhD;
Willek J van der Giessen¹, MD, PhD; Jurgen Ligthart¹, DSc; Evelyn Regar¹, MD, PhD;
Patrick W Serruyts¹*, MD, PhD

¹ J. Thoraxcenter, Erasmus MC, Rotterdam, The Netherlands; 2. Cardiolysis BV, Rotterdam, The Netherlands

In-vivo Comparison
between IVUS vs. OFDI
Quantitative assessment

<table>
<thead>
<tr>
<th></th>
<th>OFDI</th>
<th>IVUS</th>
<th>p value</th>
</tr>
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<tbody>
<tr>
<td><strong>Non-stented segment (n=40)</strong></td>
<td></td>
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<tr>
<td>Mean lumen area, mm²</td>
<td>7.04 ± 2.74</td>
<td>&lt; 8.54 ± 2.96</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Minimal lumen area, mm²</td>
<td>5.53 ± 3.34</td>
<td>&lt; 6.68 ± 3.27</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

n=59

\[ y = 0.8343x + 0.2481, r^2 = 0.8001, p<0.001 \]

![Graph showing correlation between OFDI and IVUS measurements.](image)
Diagnostic efficiency: IVUS and OCT

Stenoses with intermediate angiographic severity, FFR<0.80

- OCT MLA (AUC=0.70; 95% CI 0.55-0.83)
  - Optimal cutoff 1.95 mm²
- IVUS MLA (AUC=0.63; 95% CI 0.47-0.77)
  - Optimal cutoff 2.36 mm²

OCT vs. standard imaging

OCT penetration vs. **plaque composition**

Penetration **max** for **fibrotic** tissue (A)

**Progressively less** for

- Calcific (B)
- Lipid (C)
- Thrombus (D)
Plaque Erosion

Optical Coherence Tomography Guidance in Management of Acute Coronary Syndrome Caused by Plaque Erosion

Haibo Jia, MD, PhD; Takashi Kubo, MD, PhD;
Takashi Akasaka, MD, PhD; Bo Yu, MD, PhD

<table>
<thead>
<tr>
<th>Table. OCT Definitions of ACS Culprit Lesions</th>
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<tbody>
<tr>
<td><strong>Lesion type</strong></td>
</tr>
<tr>
<td>Plaque erosion</td>
</tr>
<tr>
<td>Definite OCT-erosion</td>
</tr>
<tr>
<td>Probable OCT-erosion</td>
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<tr>
<td></td>
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<tr>
<td>Plaque rupture</td>
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<tr>
<td>Calcified nodule</td>
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</table>
RAO caudal projection: Arrow depicting an in-stent filling defect corresponding to thrombus...
PCI

Loading @ ASA 325 mg & Ticagrelor 180 mg, Heparin 100 IU/kg

RAO caudal projection: LAD post-stenting @ 3/15 mm DES.

LAO cranial projection: LAD post-stenting
RAO caudal projection: 90% stenosis of the LAD distal to the new DES. TIMI-III flow => spasm?

Four ds later high grade AV-block, temp PCM inserted, ECHO: apical LV thrombus. Decision to re-cath…
1. OCT of the stented region. Well apposed stent in stent struts [brilliant points with sharp dark shadows (new stent asterisks, old stent arrows)]

2. OCT of the distal part of the stent, slight stent deformation, no evidence of edge dissection

3. OCT beyond the stented region. Intraluminal red thrombus (region enclosed in white line)

4. OCT distal to the thrombosed segment
STEMI: Inferior wall...
Coro: LAD/D1 100%, Atheromatous RCA, LCx ok…

Ticagrelor reloading 180 mg, UFH 100/kg, LAD stented @ 2.75/22 mm DES

However, retrospective reviewing of the coro reveals in RCA a potentially ulcerated plaque evident in only 1 frame.
8 hrs later...

LVEF 45% antero-apical akinesia

8 hrs later chest pain recurrence @ ST elevation inf. Leads (same pattern with initial ECG) => resolution @ IV Nitrates...

New Coro: 99% RCA stenosis, full resolution @ IC Nitrates, LAD ok...

IVUS: ruptured plaque (*)

MLA 7.1 mm² operator decides conservative Tx...
12 hrs following 2\textsuperscript{nd} coro: STEMI inferior wall…

- Amlodipine 5 mg o.d. + TTS NTG 5 mg…

- 12 hrs later multiple episodes of chest pain recurrence @ ST elevation inf. leads despite vasodilatation …

- 3\textsuperscript{rd} Coro & OCT: Ruptured plaque @ large necrotic core, no thrombus…

- Operator decides stenting…

Direct Stenting @ 4/18 mm DES (based on OCT measurements)
OCT vs. IVUS: Superior imaging quality...
Fig. 2  Intraluminal filling defect noted on coronary angiography proximal to an LAD segment stented 8 weeks earlier (A). IVUS revealed an intimal flap at the site of the filling defect with compromise of the arterial lumen. Arrow heads—dissection flap, *—false lumen, L—true lumen, P—plaque, C—IVUS catheter.
NSTEMI => Coro: RCA, LCx normal…

LAO cranial view: Ambiguous lesion at LAD-Dg bifurcation
OCT recording of the LAD showing thrombus and ruptured atheromatous plaque.
Patient with anterior wall ischemia

OCT of SVG lesion…

TCFA at the level of rupture

Patras University Hospital

LAD free of irregularities, apart from a hazy appearance in the proximal segment...

Proximal LAD (white arrow on angiogram) **substantial atheroma** within the arterial wall...

Bottom right: significant ulceration (5 o’clock) at the site of the grey arrow on the angiogram...
NSTEMI => Coro: LAD-CTO, RCA 40%, LCx ok…

RAO caudal view: Totally occluded LAD

LAO view: prox 40% RCA stenosis
OCT imaging: Possible Erosion…

OCT recording of the proximal RCA lesion showing possible erosion of calcified plaque…
**Conclusions**

PE is an essential mechanism of ACS. The emergence of OCT has shed new light on the identification of PE in vivo: it has well-preserved vessel lumen, less pan-vascular vulnerability and relatively large lumen area. Patients with PE will benefit from antithrombotic therapy alone, avoiding the implantation of stents. Nevertheless, future studies are needed to validate this new therapeutic approach.

**Figure 1.** Pathological features of ruptured plaque and eroded plaque. STEMI, ST-elevation myocardial infarction.
USAP: LAD spontaneous dissection...
Inf STEMI...

Three normal layers (I, M, A)

Normal Vessel (distal)

Dissection (distal)

Patras University Hospital
DES LST: Stent malaposition...
NSTEMI: LAD filling defect...
Περιφερικό

Κεντρικό
IVUS vs. OCT: Thrombus

- The criteria most commonly used for the diagnosis of thrombus on IVUS include the presence of an **echo-dense structure** within the lumen or adjacent to the arterial wall or a stent without any evidence of blood flow inside...
Although, IVUS affords excellent sensitivity for the detection of **mural calcification** and **coronary dissection**, **no pathognomonic features of thrombi on IVUS examination have been described** and **coronary angioscopy** remains the gold standard for its diagnosis....
11/2018 => NSTEMI (chest pain @ minor hsTn elevation), Coro: LAD stents ok, LM 60% ostial angiographic stenosis, **MLA 6.1 mm²** However pressure drop…

On the ground of angiographic anatomy, pressure drop upon catheter engagement, and borderline MLA, operator decides to implant a stent spanning from LM ostium to proximal LAD…

Stent positioning 4/12 mm DES, 18 atm LCx compromise Kissing 2.5/20+2.5/15 IVUS/Angio result judged satisfactory
Clinical Course…

- During subsequent ds, worsening angina at maximum effort

- **Ranolazine 375 mg b.d.** => persistence of symptoms => SPECT… Despite normal SPECT, physician adds **amlodipine 5 mg o.d.**

- 12/2018 Patient develops typical USAP while compliant with his treatment…
12/2018 Typical USAP: New coro (4rth in 4 months…)

CORO: LM stent patent, ostial LCx 80-90%, LAD stents patent, RCA 50%. However, angiographic evidence of dissection flap between LM stent and proximal LAD stent. Operator decides to perform OCT

OCT imaging discloses major dissection starting after the LM stent. (TL: True Lumen, FL: False Lumen, DF: Dissection Flap)
OCT guided PCI performance and optimization…

1. Implantation of a 3.5/16 mm DES, 18 atm

2. Final result

3. Post Stenting OCT: No residual dissection, well apposed 2nd LAD stent

4. OCT recording from LAD to LM ostium: Significant LM stent deformity due to calcified plaque...

5. Operator decides to perform LM post-dilatation and DEB in LCx ostium…
OCT guided PCI performance and optimization...

1. LM post-dilatation 4/12 mm NC balloon at 22 atm

2. DEB dilatation of LCx ostium (2.5/15 mm)

3. Final result

4. Post dilatation LM OCT

5. LCx ostium
**Clinical Highlights from ILUMIEN II**

#1. OCT’s ability to achieve superior resolution compared to IVUS allows for perfection of PCI.

### OCT vs IVUS

<table>
<thead>
<tr>
<th>Imaging Findings</th>
<th>OCT</th>
<th>IVUS</th>
<th>P value</th>
</tr>
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<tbody>
<tr>
<td>Post-PCI Malapposition</td>
<td>26.6%</td>
<td>13.6%</td>
<td></td>
</tr>
<tr>
<td>Post-PCI Tissue Protrusion</td>
<td>63.6%</td>
<td>27.3%</td>
<td></td>
</tr>
<tr>
<td>Post-PCI Stent Edge Dissection</td>
<td>23.1%</td>
<td>5.2%</td>
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</table>

### Major Finding

- **Malapposition**
  - OCT guidance: 76 (26.6%)
  - IVUS guidance: 39 (13.6%)
  - P value: 0.0002

- **Tissue protrusion**
  - OCT guidance: 182 (63.6%)
  - IVUS guidance: 78 (27.3%)
  - P value: <0.0001

- **Stent edge dissection**
  - OCT guidance: 66 (23.1%)
  - IVUS guidance: 15 (5.2%)
  - P value: <0.0001

---

Major edge dissection is imaged better with OCT...

Maehara et al. JACC Cv Intv 2015
<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Class&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Level&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVUS or OCT should be considered in selected patients to optimize stent implantation.</td>
<td>IIA</td>
<td>B</td>
</tr>
<tr>
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<td>603,612,651–653</td>
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<tr>
<td>IVUS should be considered to optimize treatment of unprotected left main lesions.</td>
<td>IIA</td>
<td>B</td>
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<td>35</td>
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</table>
Μη πιστεύετε λέξη από όσα είπε ο καρναβαλιστής!