Assessment of vulnerable plaque by OCT

Comparison with histology and possible clinical applications

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Identification of vulnerable plaque

- Plaque prone to rupture

  - Rupture (-)
  - Rupture (+)

  - Event (-)
  - Event (+)

  - UAP
  - AMI

  - Sudden cardiac death

  - **in vivo**
  - **in vitro**
Pathohistology of vulnerable plaque (HE stain)

Thin fibrous cap
Large lipid core
Advanced atherosclerosis
Pathohistology of vulnerable plaque

- Positive remodeling
- Eccentric plaques
- Lipid-rich plaques (necrotic core)
- Thin fibrous cap (< 65 μm)
- Rupture (60%) or ulceration (30~40%) of fibrous caps
- Thrombus formation
- Macrophage accumulation
Pathohistology of vulnerable plaque

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<table>
<thead>
<tr>
<th>OCT vs histology</th>
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<th>OCT vs histology</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fibrous</strong></td>
<td><strong>Lipid pool</strong></td>
<td><strong>Calcific</strong></td>
</tr>
<tr>
<td><img src="image1" alt="Fibrous" /></td>
<td><img src="image2" alt="Lipid pool" /></td>
<td><img src="image3" alt="Calcific" /></td>
</tr>
<tr>
<td>Homogeneous, Signal-rich</td>
<td>Echolucent, Diffuse Borders</td>
<td>Echolucent, Sharp Borders</td>
</tr>
</tbody>
</table>

*Yabushita et al. Circulation, 2002*
Fibrous plaque

1mm
Fibrocalcific plaque
Fibro-lipidic plaque
## Tissue characterization by OCT and IVUS


<table>
<thead>
<tr>
<th>Pathohistological Diagnosis</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Predictive Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Positive</td>
</tr>
<tr>
<td>OCT image</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fibrous (n=43)</td>
<td>79</td>
<td>99</td>
<td>97</td>
</tr>
<tr>
<td>Fibrocalcific (n=82)</td>
<td>96</td>
<td>88</td>
<td>89</td>
</tr>
<tr>
<td>Lipid (n=41)</td>
<td>85*</td>
<td>94</td>
<td>83*</td>
</tr>
<tr>
<td>IVUS image</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fibrous (n=43)</td>
<td>88</td>
<td>86</td>
<td>69</td>
</tr>
<tr>
<td>Fibrocalcific (n=82)</td>
<td>98</td>
<td>96</td>
<td>96</td>
</tr>
<tr>
<td>Lipid (n=41)</td>
<td>59</td>
<td>97</td>
<td>86</td>
</tr>
</tbody>
</table>

Data are demonstrated as percentages. *p<0.05 vs IVUS

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Pathohistology of vulnerable plaque assessment by OCT

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Study Design

Oral aspirin (162 mg) and intravenous heparin (100 U/kg) were administered before PCI.

Cardiac catheterization was performed by the femoral approach, using a 7F sheath and catheters.

- **Thrombectomy**  *(Export catheter ® Medtronic Japan)*
  - TIMI grade III
  - **IVUS** *(Atlantis SR Pro® 2.5F, 40-MHz; Boston Scientific, Natick, MA, USA)*
  - **CAS** *(Angioscope MC-800E and the optic fiber AS-003, Nihon Kohden)*
  - **OCT** *(ImageWire®; LightLab Imaging, Westford, MA, USA)*
Inferior AMI (71y. M)
Inferior-AMI (71y.o., M) Plaque Rupture

- **Ruptured Fibrous Cap**
- **Fibrous Cap Thickness**
  - $= 40 \mu m$

**TL**: True Lumen
**UL**: Ulceration
Anteroseptal AMI  (80y.o., M)

Fibrous cap thickness = 60 μm
Thickness of fibrous caps
Histology vs OCT


\[ y = 0.98x - 16.52 \]
\[ r = 0.92, \ p < 0.001 \]
Anteroseptal AMI (80y.o., M)
Anteroseptal AMI (80y.o., M)

↑ Erosion (Ulceration)
↑ Thrombus
Inf-AMI (71y.o., M)  Thrombus

Red Thrombus

Integrity Half Distance
= 135 \mu m

Thrombectomy

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Thrombus

OCT

CAS

IVUS

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Differentiation between red and white thrombus

Red thrombus
- Peak intensity: 130±18
- Distance from peak to half intensity: 183±42

White thrombus
- Peak intensity: 145±34
- Distance from peak to half intensity: 324±50 *

* p = 0.0001
## Comparison of plaque Images in AMI

**OCT vs. CAS vs. IVUS** n=30


<table>
<thead>
<tr>
<th></th>
<th>OCT</th>
<th>CAS</th>
<th><strong>IVUS</strong></th>
<th>*p</th>
<th>**p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plaque Rupture (%)</td>
<td>73</td>
<td>47</td>
<td>40</td>
<td>0.035</td>
<td>0.009</td>
</tr>
<tr>
<td>Ulceration (erosion) (%)</td>
<td>23</td>
<td>3</td>
<td>0</td>
<td>0.022</td>
<td>0.005</td>
</tr>
<tr>
<td>Thrombus (%)</td>
<td>100</td>
<td>100</td>
<td>33</td>
<td>1.000</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Red thrombus (%)</td>
<td>100</td>
<td>90</td>
<td>-</td>
<td>0.076</td>
<td>-</td>
</tr>
<tr>
<td>White thrombus (%)</td>
<td>100</td>
<td>93</td>
<td>-</td>
<td>0.150</td>
<td>-</td>
</tr>
<tr>
<td>TCFA (≤65 μm) (%)</td>
<td>85</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fibrous cap thickness (μm)</td>
<td>59±13</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LRP (Lipid Arch&gt;120°) (%)</td>
<td>57</td>
<td>-</td>
<td>67</td>
<td>-</td>
<td>NS</td>
</tr>
</tbody>
</table>

**p** < 0.05

TCFA; Thin Cap Fibro-Atheroma, LRP; Lipid Rich Plaque
Pathohistology of vulnerable plaque
Assessment by OCT

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OCT findings

Low M\(\phi\)  High M\(\phi\)

CD68 (macrophage)
Macrophages
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Summary
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Conclusions

- OCT can identify lipid-rich plaques more sensitively compared with IVUS.

- OCT can demonstrate rupture or erosion of fibrous cap with higher detection rate than that of IVUS and CAS.

- OCT could detect intracoronary thrombus almost exclusively which was confirmed by CAS.

- OCT may estimate macrophage accumulation within fibrous caps.