Identification of Vulnerable Plaque by IVUS

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82 yr old female
Risk factors: Type 2 DM, Hyperglycemia
LAD PCI because of NSTEMI
Standard medical treatment
Unstable Angina 3 months after LAD PCI
ECG indicates inferior ischaemia
Number of thin-cap fibroatheromas in patients dying with MI, sudden death, or noncardiac causes and studied at necropsy using *cross-sectional analysis*.

*(Burke et al. J Am Coll Cardiol 2003;41:1874-86-)*
Vulnerable Plaque

- Large necrotic lipid core
- Thin fibrous cap
- Dense Macrophage infiltration (metalloproteinases)
- Progressive matrix degeneration
- Paucity of SMCs
- Angiographically non-significant
- Positive remodelling
- Inflammation

68%AMI occurred on the stenosis <50%
Identification of Vulnerable Plaques

Focal lesion

Diffuse lesion

Limitation lesion

Diffuse lesion
• Large eccentric plaque containing an **echolucent area** on grayscale IVUS can be at increased risk for future acute event
  

• The test of concordance for echolucent area visualization by 2 independent observers was 0.68

  *Prati F, et al. Circulation 2003*
Correlation between high frequency intravascular ultrasound and histomorphology in human coronary arteries

F Prati, E Arbustini, A Labellarte, B Dal Bello, L Sommariva, M T Mallus, A Pagano, A Boccanelli

In 122 cross-sections (12 arteries), lipid pools observed by histology in 30, revealed by IVUS in 19 (sensitivity 65% and specificity 95%)
Plaque Composition in Acute Coronary Syndromes

Schoenhagen et al. Circulation 2000;101:598-603
Identification of Vulnerable Plaques
Identification of Vulnerable Plaques
<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pts (n)</td>
<td>31</td>
<td>108</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>87%</td>
<td>85%</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>55</td>
<td>58</td>
</tr>
<tr>
<td>Hypertension</td>
<td>61%</td>
<td>45%</td>
</tr>
<tr>
<td>Diabetes</td>
<td>23%</td>
<td>23%</td>
</tr>
<tr>
<td>Smoking</td>
<td>68%</td>
<td>57%</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>74%</td>
<td>41%*</td>
</tr>
<tr>
<td>Family history</td>
<td>35%</td>
<td>41%</td>
</tr>
<tr>
<td>Obesity</td>
<td>32%</td>
<td>35%</td>
</tr>
<tr>
<td>Symptoms (unstable)</td>
<td>74%</td>
<td>18%*</td>
</tr>
</tbody>
</table>

* p<0.01

Ge et al, Heart 1999
### Identification of Vulnerable Plaques

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group A</th>
<th>Group B</th>
</tr>
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<tbody>
<tr>
<td><strong>Thickness of the cap</strong></td>
<td>0.47 ± 0.20</td>
<td>0.96 ± 0.94*</td>
</tr>
<tr>
<td><strong>Tear size</strong></td>
<td>0.83 ± 0.29</td>
<td>-</td>
</tr>
<tr>
<td><strong>Eccentric</strong></td>
<td>94%</td>
<td>64%*</td>
</tr>
<tr>
<td><strong>Plaque size</strong></td>
<td>11.7 ± 7.0</td>
<td>13.4 ± 6.3</td>
</tr>
<tr>
<td><strong>Lipid core size</strong></td>
<td>4.1 ± 3.2</td>
<td>1.3 ± 0.8*</td>
</tr>
<tr>
<td><strong>Lipid/plaque ratio</strong></td>
<td>38.5 ± 17.1%</td>
<td>11.2 ± 8.9%*</td>
</tr>
<tr>
<td><strong>Percent stenosis</strong></td>
<td>56.2 ± 16.5%</td>
<td>67.9 ± 13.4%*</td>
</tr>
<tr>
<td><strong>Superfacial calcium</strong></td>
<td>52%</td>
<td>51%</td>
</tr>
<tr>
<td><strong>Deep calcium</strong></td>
<td>17%</td>
<td>43%*</td>
</tr>
</tbody>
</table>

* = p < 0.05

Ge et al, Heart, 1999
Identificaton of Vulnerable Plaques

♦ IVUS is able to identify vulnerable plaques.
♦ The characteristics of vulnerable plaques include
  • Echolucent area $>1\text{mm}^2$;
  • Echolucent area/plaque ratio $>20\%$;
  • Thickness of fibrous cap $<0.7\text{mm}$. 
Vulnerable plaque: soft and eccentric

Wu HY, Chinese J Cardiol 2005; 33:894-898
Vulnerable plaque: rupture and thrombogenesis

Wu HY, Chinese J Cardiol 2005; 33:894-898
Identification of Vulnerable Plaques (Summary)

- Wu H, Ge J. *Chin J Cardiol* 2005;33:894
IVUS - What is Unproven

- Will this morphologic characteristic plaque rupture?
- When will it rupture?
- What is the consequence after rupture?
IVUS- What is Unproven

Angiography: Dia. stenosis 14%
Area stenosis 26%


IVUS: Dia. stenosis: 46%
Area stenosis: 74%
IVUS - What is Unproven

- Silent healing of spontaneous rupture, an IVUS follow-up

---Ge J, et al.
Eur Heart J 1994
IVUS- What is Unproven

Pre-intervention
CFVR=1.7

After stenting
CFVR=3.0

55 yr old male
SAP
48 yr old male
UAP

Pre-intervention
CFVR=2.0

After stenting
CFVR=2.5
58 yr old female, UAP

Pre-intervention, CFVR=1.7

After stenting, CFVR=1.6
Angiography: Dia. stenosis: 14%
Area stenosis: 26%

IVUS: Dia. stenosis: 46%
Area stenosis: 74%

„Plaque at risk“ to rupture
Virtual Histology (VH)-Thin Cap Fibroatheroma

“Thin Cap Fibro-Atheroma (TCFA)” or “Vulnerable Plaque” -- Confluent Necrotic Core >10% of total plaque, >33% of lesion circumference at the lumen surface, and present in 3 consecutive frames. Based on the presence or absence of Ca, the length of the NC, or signs of previous ruptures, TCFA can be further sub-classified

Still further sub-classification can be based on presence of luminal narrowing.

“TCFA without significant narrowing” - plaque burden <50% on IVUS and/or less than 25% narrowing on angiogram. (Pathologic data suggests that TCFA without significant plaque burden are less “vulnerable”)

“Highest Risk TCFA”

a. Confluent NC>20%
b. No evidence of fibrotic cap
c. Calcium >5%
d. Remodeling index >1.05
e. >50% plaque burden by IVUS

(Pathologic data suggests that TCFA with significant plaque burden are the most vulnerable)