Disclosure

- VH is licenced to Volcano Therapeutics
- Grant funding from Pfizer, Inc.
- Grant funding from Boston-Scientific
Most Myocardial Infarctions are Caused by Low-Grade Stenoses

Coronary stenosis severity prior to MI

- >70% Stenosis: 14%
- 50%-70% Stenosis: 18%
- <50% Stenosis: 68%

The “Vulnerable” Coronary Plaque

- Necrotic core
- Lumen
- Fibrous Cap
The association between positive arterial remodeling and plaque vulnerability has been demonstrated in vitro and with in-vivo intravascular ultrasound studies.

Direction of Remodeling and Clinical Presentation

Schoenhagen et al. Circulation 2000;101:598-60
Vulnerable Plaques

Geometry and composition may play a role?

- IVUS provides accurate geometry
- Composition is a little more difficult
VUS

A

B

The Cleveland Clinic Foundation
Previous histological studies have demonstrated that the discrimination of lipid is inconsistent using video images alone.

- Palmer et al. Eur Heart J., 1999
- Peters et al. Circulation, 1994
IVUS – Listening through walls

US signal

Backscattered signal or RF data

Backscattered signal or RF data

Lumen

Vessel

Lipid
IVUS Image Formation

Envelope Detection
IVUS Image Formation

Maximum Echo Intensity

Minimum Echo Intensity

Convert to gray-scale and log-compress
Echo intensity lines are scaled and scan converted via bilinear interpolation to make the ultrasonic image.
Only the envelope amplitude (echo intensity) is used in formation of the gray-scale IVUS image.

Frequency of echo signal can also vary, depending on the tissue.
Teaching the Computer
Do the different frequencies correspond to different types of tissue?

- Calcium
- Fibrous
- Fibro-lipidic
- Lipid core
Geometrical Measurements

- Number of Frames:
- Average Lumen Cross-Sectional Area:
- Average Vessel Cross-Sectional Area:
- Average Plaque+Media Cross-Sectional Area:
- Average Percent Occlusion:
- Lumen Volume:
- Vessel Volume:
- Plaque Volume:
- Frame Position

- For every frame:
  - Lumen Cross-Sectional Area
  - Lumen Perimeter Length
  - Lumen Maximum Diameter
  - Lumen Minimum Diameter
  - Lumen Eccentricity (Min/Max)
  - Plaque Cross-Sectional Area
  - Plaque Maximum Thickness
  - Plaque Minimum Thickness
  - Plaque Eccentricity (Min/Max)
  - Percent Occlusion
  - Remodelling Index
  - And more!!
Compositional Measurements

- Average Fibrous Cross-Sectional Area:
- Average Fibro-Lipidic Cross-Sectional Area:
- Average Calcified Cross-Sectional Area:
- Average Lipid Core Cross-Sectional Area:
- Average Media Cross-Sectional Area:
- Fibrous Volume:
- Fibro-Lipidic Volume:
- Calcified Volume:
- Lipid Core Volume:

For every frame:
- Calcified Cross-Sectional Area
- Calcified %
- Fibrous Cross-Sectional Area
- Fibrous %
- Fibro-Lipidic Cross-Sectional Area
- Fibro-Lipidic %
- Lipid Core Cross-Sectional Area
- Lipid Core %
Volume Plots

Lipid Core Cross-Sectional Area
Fibro-Lipidic Cross-Sectional Area
Fibrous Cross-Sectional Area
Calcified Cross-Sectional Area
Media Cross-Sectional Area

Frame Number
CSA (mm²)

Distal
Proximal
Fibrous; Fibro-lipidic; Lipidic-necrotic; Calcium
# Ex-vivo validation

<table>
<thead>
<tr>
<th></th>
<th>Fibrous (n=101)</th>
<th>Fibro-Lipidic (n=56)</th>
<th>Calcified (n=50)</th>
<th>Lipidic-Necrotic (n=70)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VH Accuracy</td>
<td>79.7%</td>
<td>81.2%</td>
<td>89.5%</td>
<td>85.5%</td>
</tr>
</tbody>
</table>
Accurate – *in vivo* validation

- Test accuracy of VH in patients
  - Dr Columbo, Italy
  - Drs Suzuki and Katoh, Japan
- IVUS followed by DCA
  - Guidant flex-cut
  - Fox Hollow
- Histology
  - True “gold-standard”
In vitro vs In vivo histo (ZC)

- Lipidic necrosis
- Fibrous

The Cleveland Clinic Foundation
In vitro vs in vivo histo (GB)
IVUSLab Analysis System

- Provides data on vessel geometry
- Provides Virtual Histology™
Future studies

- VH built into IVUS system
  - EagleEye tree in Q2, 2004
  - “Real-time” capabilities
  - Automatic border detection
- Interface & Display
Team Cleveland

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