Detection and Treatment of Thin Fibrous Cap, Lipid Rich and Inflammatory Vulnerable Plaque – Angioscopic Evaluation

Kyoichi Mizuno, M.D., PhD., FAHA, FACC, FSCAI
Chiba Hokusoh Hospital, Nippon Medical School

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TCT Asia Pacific, Seoul
Characteristics of coronary angioscopy

1. full color
2. high resolution
3. three dimension
Coronary angiography, IVUS and angioscopy
Today’s headline

1. Angioscopic classification

2. Comparison between angioscopic macromorphology and microscopic histopathology

3. Treatment of vulnerable plaque

   Statin

   Coronary intervention
~Classification of angioscopic findings~

<table>
<thead>
<tr>
<th></th>
<th>Plaque</th>
<th>Thrombus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>color</strong></td>
<td>yellow, white</td>
<td>red, white</td>
</tr>
<tr>
<td><strong>shape</strong></td>
<td>smooth, complex</td>
<td>occlusive, non-occlusive</td>
</tr>
<tr>
<td></td>
<td>rupture flap,</td>
<td>mural(lining), intraluminal</td>
</tr>
</tbody>
</table>
Today’s headline

1. Angioscopic classification

2. Comparison between angioscopic macromorphology and microscopic histopathology

3. Treatment of vulnerable plaque
   Statin
   Coronary intervention
Sudan III
Fibrous cap
H–E stain
Sudan III
Thickness of fibrous cap

![Graph showing thickness of fibrous cap with labels for yellow and white colors, and significance level p<0.001.](image)
Comparison between angioscopic plaque color and histomorphology entitles of 44 atherectomy Specimens

![Bar chart showing angioscopic surface colors and histomorphology entitles.](image)

Angioscopic surface color

Thieme T et al. JACC 1996;20:1
Yellow plaque and macrophage
Comparison between hs CRP levels and Plaque color

0.07 ± 0.0 vs. 0.17 ± 0.16 mg/dL, p = 0.005,
The frequency of yellow plaque

Fibrous cap: thin, thick
Inflammation: +, –
Lipid pool: large, small
Vulnerable, Stable
Today’s headline

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   Coronary intervention
Background

There have been no reliable methods to examine the plaque stabilization in living patients.

Color and morphology of coronary plaque are regarded as determinant factor of plaque stability and instability.
### Landmark Intervention Trials using Statins

<table>
<thead>
<tr>
<th>LDL Level</th>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>High LDL</td>
<td>WOSCOPS (192, 159, -26%) (-22%, -31%)</td>
<td>4S (188, 122, 35%) (-30%, -34%)</td>
</tr>
<tr>
<td></td>
<td>AFCAPS/T EXCAPS (156, 115, 25%) (0%, -37%)</td>
<td>CARE (139, 98, 32%) (-9%, -24%)</td>
</tr>
<tr>
<td></td>
<td>LIPID (150, 112, 25%)</td>
<td></td>
</tr>
</tbody>
</table>

### Hazard rate per year for target (stented) lesion and non target (non stented) lesion after stenting

<table>
<thead>
<tr>
<th>Year</th>
<th>Non Stented</th>
<th>Stented</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>20%</td>
<td>15%</td>
</tr>
<tr>
<td>2 years</td>
<td>15%</td>
<td>10%</td>
</tr>
<tr>
<td>3 years</td>
<td>10%</td>
<td>5%</td>
</tr>
<tr>
<td>4 years</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>5 years</td>
<td>2%</td>
<td>1%</td>
</tr>
</tbody>
</table>

© Landmark Intervention Trials using Statins
Hypothesis

Lipid lowering therapy and stenting induce plaque stabilization
Aim

Investigation of the effect of statin and stenting on plaque stabilization using coronary angioscopy.

Chiba Hokusoh Hospital, NMS
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Objective

Changes in coronary plaque color and morphology by statin were evaluated using coronary Angioscopy.
Ischemic Heart Disease, PCI for Culprit Lesions
Yellow Plaques in Non-Culprit Lesions detected by angioscopy

- **T-CHO ≥ 220mg/dL**: Baseline 0 month
  - **Atorvastatin (+)**: N = 16
  - 12 Months: Target LDL-C < 100mg/dL

- **T-CHO < 220mg/dL**: Baseline 0 month
  - **Atorvastatin (-)**: N = 15
  - 12 Months: Diet Therapy

Angioscopy for Evaluation the Same Plaques in Non-Culprit Lesions
Score of the plaque color and complexity

White

0: without irregular

Yellow

2

0: without irregular

1 Light yellow

3 Dark yellow

irregular

1

0: without thrombus

thrombus

1

0: without thrombus
Changes of angioscopic findings from baseline to follow-up

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Atrovastatin</th>
<th>Follow-up</th>
<th>Baseline</th>
<th>Control</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y (score)</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>D (ties)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Baseline Angioscopic Images

Follow-up Angioscopic Images
Changes in mean yellow score from baseline to follow-up

<table>
<thead>
<tr>
<th>Group</th>
<th>Baseline</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrovastatin (n=16)</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>Control (n=15)</td>
<td>1.4</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Comparison vs. Atrovastatin

Atrovastatin vs. Control:
- Baseline vs. Follow-up: P = 0.04
- Baseline vs. Follow-up: P < 0.0001
Changes in mean disrupted score from baseline to follow-up

Comparison vs. Atrovastatin

Baseline vs. Follow-up

Atrovastatin (n=16)
Control (n=15)

P=0.04
P=0.02
P=0.64
P=0.004

Baseline Follow-up
LDL-C lowering by atrovastatin resulted in the reduction of angioscopic yellow grade and complexity of coronary plaque.

Lipid lowering therapy changed the quality of coronary plaque and should lead to coronary plaque stability.
Today’s headline

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   - Statin
   - Coronary intervention
Objective

The morphologic changes in infarcted-related lesions after stenting in acute myocardial infarction or recent myocardial infarction were investigated with coronary angioscopy.
Patients and methods

Coronary angioscopy (acute myocardial infarction N=28, post infarction angina N=15) was serially performed for the infarcted related lesions at baseline, after balloon inflation, and after stenting following balloon angioplasty and at one and six months after stenting.
Angioscopic findings

Plaque
- yellow
- white
- smooth
- irregular

Thrombus
- protruding
- lining (mural)
Stent coverage
as Assessed by Angioscopy

**Stent coverage score** (semi-quantitatively visual evaluation)

0: complete exposure of stent struts
1: exposure of stent struts with partial coverage
2: > 50% coverage of stent struts
3: almost complete coverage with slightly visible stent struts
4: complete coverage of stent struts
Stent coverage score

Grade 0 | Grade 1 | Grade 2 | Grade 3 | Grade 4
Acute STEMI

Stent coverage score = 1

Stent coverage score = 4

After POBA

After stenting
Changes in Plaque Surface (A) and Color (B) After Stenting (6-month Follow-Up)

A

Immediately after stenting
n=39

1-month follow-up
n=36

6-month follow-up
n=30

<table>
<thead>
<tr>
<th></th>
<th>Smooth</th>
<th>Irregular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediately</td>
<td>100</td>
<td>19</td>
</tr>
<tr>
<td>1-month follow-up</td>
<td>81</td>
<td>3</td>
</tr>
<tr>
<td>6-month follow-up</td>
<td>97</td>
<td>3</td>
</tr>
</tbody>
</table>

p<0.01

B

immediately after stenting
n=39

1-month follow-up
n=36

6-month follow-up
n=30

<table>
<thead>
<tr>
<th></th>
<th>White</th>
<th>Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>immediately</td>
<td>97</td>
<td>3</td>
</tr>
<tr>
<td>1-month follow-up</td>
<td>94</td>
<td>6</td>
</tr>
<tr>
<td>6-month follow-up</td>
<td>93</td>
<td>7</td>
</tr>
</tbody>
</table>

p<0.01

Sakai, Mizuno, et al. JACC 2003; 42:
Changes in the Incidence of thrombus

- Base line
- Immediately after balloon angioplasty
- Immediately after stenting
- 1-month follow up
- 6-months follow up

Protruding thrombus
Lining thrombus
Immediately after stenting 1-month follow-up 6-month follow-up

<table>
<thead>
<tr>
<th></th>
<th>Immediately after stenting</th>
<th>1-month follow-up</th>
<th>6-month follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>n=39</td>
<td>(n=1)</td>
<td>(n=1)</td>
<td>(n=1)</td>
</tr>
<tr>
<td>n=36</td>
<td>(n=25)</td>
<td>(n=8)</td>
<td>(n=5)</td>
</tr>
<tr>
<td>n=30</td>
<td>(n=2)</td>
<td>(n=2)</td>
<td>(n=24)</td>
</tr>
</tbody>
</table>

Sakai, Mizuno, et al. JACC 2003; 42: 1558
Summary

1. At baseline, most of the lesions had complex morphology, yellow plaque color, and protruding thrombus.
2. After stenting, the protruding thrombus and intimal flap disappeared.
3. At one-month-follow up, irregular and yellow surface, along with a lining thrombus, is still observed.
4. At six months follow-up, the neointima was found to have sufficiently formed over the stent.
Vulnerable plaque

Lipid-lowering therapy
(statins)

Plaque lipid decreased
Mature collagen increased

Mechanical plaque sealing

Vulnerable plaque
Thin fibrous cap
Large lipid core

PCI
(stenting)

Stent strut

Neointimal hyperplasia
Conclusion

Coronary angioscopy is an excellent tool with which to approach the unanswered question regarding plaque vulnerability and the effect of treatment in living patients.