Comparison between New Labeling Method of MDCT and Virtual Histology of IVUS for Non-Calcified Plaque Analysis

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Background

It is often difficult to classify into soft plaque and fibrous plaque by differences of CT attenuation, because there were many overlaps between CT density of soft and fibrous plaques, and the CT attenuation was influenced by lumen contrast density or lesion calcification.

The purpose of this study is to evaluate new plaque analyzing software (Labeling method) that is not dependent on CT attenuation only, but CT image pattern.
In 2001, Stephen S et al. reported that MDCT could classify the plaque morphology by CT density only.

Stephen Schroeder et al.

Noninvasive detection and evaluation of atherosclerotic coronary plaques with multislice computed tomography

*JACC* 2001, 37: 1430-1435
Statistically, there were significant difference between the two groups, however, there were many overlaps between CT density of soft and fibrous plaques.

Therefore, that the differentiation of “vulnerable” and “stable” plaques based on their CT attenuation is doubtful.
Method

Coronary MDCT (Aquilion-64) and intravascular ultrasound (IVUS, Volcano) were performed in 24 patients (63±12y) with coronary non-calcified plaques.

IVUS image were analyzed by “Virtual Histology” that was verified by comparing with histology in many papers. Short axis MDCT images were investigated by New Labeling software.
Extraction Method of Different Characteristic Area

Statistically classify vascular structure into vascular wall, lumen, calcification, fibrous and soft plaque area depending on not only CT number but also their pattern on short axis view.

**Extraction**
Statistically evaluate not only CT number and continuity of subjects, and classify the area.

**Reunify**
Reunify the area according to CT number, position, shape and etc of subjects.
Comparison of VH-IVUS and Labeling Method on MDCT

Representative case of fibrous plaque

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumen Area</td>
<td>3.5 mm²</td>
<td></td>
</tr>
<tr>
<td>EEL Area</td>
<td>12.5 mm²</td>
<td></td>
</tr>
<tr>
<td>Plaque Area</td>
<td>9.0 mm²</td>
<td></td>
</tr>
<tr>
<td>% Plaque Burden</td>
<td>72 %</td>
<td></td>
</tr>
<tr>
<td>FI Green Area</td>
<td>5.3 mm²</td>
<td>90 %</td>
</tr>
<tr>
<td>FF Light Green Area</td>
<td>0.6 mm²</td>
<td>10 %</td>
</tr>
<tr>
<td>DC White Area</td>
<td>0.0 mm²</td>
<td>0 %</td>
</tr>
<tr>
<td>NC Red Area</td>
<td>0.0 mm²</td>
<td>0 %</td>
</tr>
</tbody>
</table>

EEL: External Elastic Lamina
Comparison of VH-IVUS and Labeling Method on MDCT

Representative case of mixed plaque
Comparison of VH-IVUS and Labeling Method on MDCT

Representative case of soft plaque

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumen Area</td>
<td>4.8 mm²</td>
</tr>
<tr>
<td>EEL Area</td>
<td>23.0 mm²</td>
</tr>
<tr>
<td>Plaque Area</td>
<td>18.2 mm²</td>
</tr>
<tr>
<td>% Plaque Burden</td>
<td>79 %</td>
</tr>
<tr>
<td>F1 Green Area</td>
<td>7.7 mm² 54 %</td>
</tr>
<tr>
<td>FF Light Green Area</td>
<td>5.0 mm² 35 %</td>
</tr>
<tr>
<td>DC White Area</td>
<td>0.3 mm² 2 %</td>
</tr>
<tr>
<td>NC Red Area</td>
<td>1.3 mm² 9 %</td>
</tr>
</tbody>
</table>
Comparison between conventional method and new labeling method

Relatively low density area; maybe lipid rich

Peripheral fatty tissue influences the edge of the vessel. And it cannot evaluate relatively low density plaque.

Necrotic core

New labeling method accurately evaluated the vessel diameter and lipid rich plaque.
Comparison of Mean CT Number between Fibrous parts and Soft Parts of the Plaque

<table>
<thead>
<tr>
<th></th>
<th>Fibrous</th>
<th>Soft</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT Number</td>
<td>62.3 +/- 15.5</td>
<td>54.3 +/- 22.6</td>
</tr>
<tr>
<td>N</td>
<td>24</td>
<td>15</td>
</tr>
<tr>
<td>P</td>
<td>0.1966</td>
<td></td>
</tr>
</tbody>
</table>

P = 0.1966
Correlation between IVUS and MDCT

EEL: External Elastic Lamina

**External Area by MDCT**

- \( Y = 1.044 + 0.871 \times X; \ R^2 = 0.729 \)

\[ R = 0.854, \ P < 0.0001 \]
\[ N = 24 \]

**Lumen Area by MDCT**

- \( Y = 2.012 + 0.712 \times X; \ R^2 = 0.544 \)

\[ R = 0.737, \ P < 0.0001 \]
\[ N = 24 \]
Correlation between IVUS and MDCT

Fibrous Area by MDCT

VH-IVUS: FI

\[ Y = 0.135 + 0.473 \times X; \quad R^2 = 0.509 \]

\[ R = 0.713, \quad P < 0.0001 \]

\[ N = 24 \]

Soft Area by MDCT

VH-IVUS: FF+NC

\[ Y = 2.575 + 0.535 \times X; \quad R^2 = 0.434 \]

\[ R = 0.659, \quad P < 0.0005 \]

\[ N = 24 \]

FI: fibrous, FF: fibro-fatty, NC: necrotic core
Conclusion

The most important point is that the MDCT is useful not only to diagnose the coronary artery disease but also to evaluate the plaque.

The conventional method could not accurately differentiate the soft plaque and fibrous plaque, however, new labeling method (software) made possible to differentiate them. Furthermore, the plaque analysis based on MDCT would distinguish ‘vulnerable’ and ‘stable’ plaque in the near future.