The Detection of Attenuated Plaque with 64-Multidetector Computed Tomography: A Comparison with Intravascular Ultrasound

Poster No.: C-1827
Congress: ECR 2011
Type: Scientific Exhibit
Authors: S. Koga, M. Jinzaki, T. okabe, A. Kawamura, A. Endo, Y. Tanami, H. Sugiuira, S. Kuribayashi; Tokyo/JP
Keywords: Cardiac, CT-Angiography, Diagnostic procedure
DOI: 10.1594/ecr2011/C-1827

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method ist strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Purpose

1. The attenuated plaque, which refers to deep ultrasound attenuation without calcification, has been reported to be associated with plaque vulnerability\textsuperscript{1}. Attenuated plaque is also thought to cause slow-flow or no-flow after percutaneous coronary intervention (PCI) because of its components such as lipid-laden atheromatous gruel mixed with foam cells and microcalcification, which might cause echo attenuation \textit{per se}\textsuperscript{1, 2, 3}.

2. At present, intravascular ultrasound (IVUS) is the only modality to detect attenuated plaque, and thus prior to PCI we were unable to assume vulnerability by the existence of attenuated plaque. If attenuated plaque is composed of lipid-laden atheromatous and microcalcification, MDCT may have the potential to demonstrate attenuated plaque as a lesion with low density area (lipid-rich lesion) and high density area (calcified lesion), and enable the detection of attenuated plaque non-invasively.

3. The aim of this study was to clarify 64-slice multi-detector computed tomography (64-MDCT) findings of attenuated plaque detected by intravascular ultrasound (IVUS).
Methods and Materials

Patient population

Out of 154 cases which underwent contrast enhanced 64-MDCT within 3 months prior to IVUS investigation at the Keio University Hospital from September 2005 to February 2009, we identified 12 stable angina pectoris patients with attenuated plaque in the culprit artery detected by IVUS. Two cases were excluded, 1 of which could not be analyzed by 64-MDCT due to severe calcification in the culprit artery, and the other had a motion artifact due to arrhythmia. As a result, 10 cases (male 10, 68 ± 10 years) were enrolled in this study. Baseline clinical characteristics and procedural variables were recorded and entered prospectively.

Coronary angiography

Angiographic analysis was performed by standard methodology to determine the locations of each example of attenuated and calcified plaque on the coronary artery in accordance with IVUS. The coronary blood flow status was determined before and after PCI in accordance with the Thrombolysis In Myocardial Infarction (TIMI) flow grade.

IVUS

IVUS was performed using the Boston Scientific (Minneapolis, MN) system incorporating a 40 MHz single-element beveled transducer (Atlantis SR Pro2) rotating at 1,800 rpm coupled with either ClearView Ultra, or an Intra Focus HF (Terumo, Japan) with a Intraimage TU-C200. All IVUS images were recorded after administration of 2-5 mg of intracoronary isosorbide dinitrate. The ultrasound catheter was advanced distally and was pulled back to the aorto-coronary ostium using a motorized transducer pullback at 0.5 mm/s. All IVUS images were recorded on s-VHS videotapes for offline analysis.

The IVUS data were analyzed by an experienced cardiologist (T.O.) who was blind to the result of 64-MDCT. The existence of attenuated plaque was identified in the culprit artery on IVUS and the existence of calcified plaque was also checked in the same coronary artery. Attenuated plaque was defined as hypoechoic plaque with deep ultrasound attenuation without calcification. The location of each case of plaque was confirmed by measuring the distance from the aorto-coronary ostium or the nearest bifurcation point. Cross-sectional area (CSA) measurements of the external elastic membrane (EEM), lumen, plaque&media (= EEM CSA - lumen CSA) (P&M), and plaque burden (= P&M CSA /EEM CSA) were performed every 1 mm over the existence of attenuation using the planimetry system installed in the IVUS system console. After calculating the EEM, lumen, and P&M volume using Simpson’s method, we compensated for the difference in the plaque lengths with the volume index (= each volume value divided by the plaque...
length). The remodeling index was defined as the mean EEM CSA over attenuated plaque divided by the mean EEM CSA of proximal and distal reference sites. The reference site was selected as the most visually normal section within 10 mm proximal and distal to the attenuated plaque, respectively. Positive remodeling was determined as a remodeling index >1.05.

MDCT

Coronary CT angiography was obtained with a 64-detector row CT (LightSpeed VCT: GE Healthcare, Milwaukee, USA). Glycerol trinitrate 0.3 mg was administered sublingually immediately before the scan. The enhanced and unenhanced images were obtained with collimation of 64 × 0.625 mm, rotation time of 0.35 seconds, pitch between 0.20 and 0.22, tube current of 350-550 mA and voltage of 120 kV. Iodine contrast material 40-60 ml (Iopamidol 370 mgI/ml) was injected at a rate of 4ml/sec, immediately followed by 20 ml of saline at the same rate. The delay between the start of injection and scanning was determined by the test bolus technique with monitoring at the level of the ascending aorta (120 kV, 20mAs, 10mL of contrast material followed by 20 mL of saline injected at 4 mL/sec). The delay applied for main scanning was calculated by the time to peak enhancement for the test bolus plus three seconds. The estimated effective radiation dose was 15-19 mSv. The raw data of the scans were reconstructed using algorithms optimized for retrograde ECG-gated multislice spiral reconstruction.

Data analysis

Axial images of both unenhanced and enhanced CT images were transferred to a standard commercially available workstation (GE Advantage Workstation 4.4). Curved multiplanar reconstruction (MPR) was initially displayed with a default window setting (level, 100 HU; window, 700 HU). The window and level of the evaluated images could then be adjusted by the observer.

One experienced technologist who was blinded to the results of conventional coronary angiography rendered stretched MPRs of the targeted coronary artery in both unenhanced and enhanced images with 0.6 mm section thickness. Two radiologists (M.J. and S.K. with 8 years and one year of experience in cardiac CT, respectively) evaluated the MDCT findings in consensus. They first confirmed the range scanned with IVUS and the location of attenuated plaque on IVUS images was then confirmed by measuring the distance from the aorto-coronary ostium or the nearest bifurcation point on stretched MPR images, and the angle on cross sectional images. The areas corresponding to the plaque demonstrated by IVUS were reported as either accompanied or unaccompanied by calcification density, this being defined as a high density area >150 HU (HDA). We divided the area without HDA into 2 categories; the low density area <30H (considered to be soft plaque), or the intermediate density area between 30 and 150 HU (considered to be fibrous plaque)⁵,⁶. Two radiologists independently evaluated the presence of a high
density area >150 HU (HDA) and a low density area < 30HU (LDA) in these arteries with MDCT. The mean attenuation of the 3 regions of interest (ROI) in the center of the calcification density was calculated. To rule out the possibility that areas depicting high density of >150HU may simply be due to the enhancement of plaque, the same area was confirmed for HDA on unenhanced images. We also identified all calcified plaques which were detected with IVUS and determined the mean attenuation of the lesion based on the 3 ROI in the center of the calcification to compare the calcification densities between attenuated and calcified plaque with IVUS.

**Statistical analysis**

Statistical analysis was performed with SPSS Version 11.0 (SPSS Inc., Chicago, IL). Continuous variables are reported as mean ± 1 SD. The difference in the characteristics between attenuated and calcified plaque was evaluated with the Student's *t*-test. A p value <0.05 was considered significant.
Results

IVUS findings

Ten attenuated plaques and 16 calcified plaques were identified in 10 of 154 (6.5%) patients (male 10, 68 ± 10 years). The baseline characteristics of these 10 patients are shown in Table 1. All but 1 had some kind of coronary risk factor, which included a prior history of PCI and chronic renal failure. The characteristics of the 10 cases of attenuated plaque and the 16 cases of calcified plaque are shown in Table 2. There were no significant differences in the IVUS parameters between attenuated and calcified plaque. The remodeling index was 1.1 ± 0.1 in cases of attenuated plaque.

Four cases in this study suffered from temporary flow deterioration at the time of the PCI procedure (TIMI flow grade 0/1; 3, grade 2; 1).

MDCT findings

Among 10 cases of attenuated plaque, 8 demonstrated HDA on MDCT. Seven of these 8 had CT density value ranged from 174 to 667 HU (mean 399.1 ± 157.2 HU, r=0.99) (Figs. 1, 2) and the other had an extreme value of 1220 HU. In these 8 cases with attenuated plaque, HDA detected on enhanced CT was also detected in the same area on unenhanced CT. Of the 8 cases of attenuated plaque with HDA, the HDA was detected in a part of the segment of attenuated plaque in 3 (Fig. 2), whereas the length of the HDA was perfectly identical to the length of the attenuated plaque on IVUS in 5 (Fig. 1). There were no cases which displayed HDA to be longer than the segment of attenuated plaque. All attenuated plaques contained the low density area <30HU in the portions without HDA (Fig. 3). In addition, the intermediate density area between 30 and 150 HU was also present in all portions without HDA.

All 16 cases of calcified plaque detected on IVUS demonstrated HDA and those CT density value ranged from 575 to 1205 HU (mean; 913.3 ± 210.7 HU, r=0.97). There was a significant difference in the CT density value of HDA between attenuated and calcified plaque (Fig. 4).
Attenuated plaque with high density area on 64-MDCT.

An instance of attenuated plaque is demonstrated in longitudinal (a) and cross sectional images (b) with IVUS in the right coronary artery. White arrows indicate the plaque positions. A plaque with linear high density is demonstrated in the same position with attenuated plaque on IVUS in the curved MPR (c) and cross sectional (d) images with 64-MDCT. The length of high density is identical to the length of attenuated plaque on IVUS. The maximum density is 280 HU in the enhanced cross-sectional CT image. The arrow head (d) shows enhanced coronary lumen. The high density corresponding to this area is also seen in the unenhanced cross-sectional CT image (e).

References: - Tokyo/JP
Fig. 2-1: Attenuated plaque with high density area on 64-MDCT.Instances of attenuated plaque (a, b: long arrows) and calcified plaque (c, d: short arrows) are demonstrated in longitudinal (a, c) and cross sectional images (b, d) with IVUS in the left anterior descending artery. Instances of attenuated plaque (e, f, g: long arrows) and calcified plaque (e, h: short arrows) are demonstrated in stretched MPR (e) and cross sectional (f-h) images with 64-MDCT in the same positions as on IVUS. The length (4 mm) of high density (e: long arrow) is smaller than the length (6 mm) of attenuated plaque on IVUS. The maximum density is 352 HU in attenuated plaque and 1127 HU in calcified plaque on enhanced CT. The high density area of attenuated plaque corresponding to the enhanced CT image is also seen in the unenhanced CT image (g). The arrow head (e) was the partial image of another calcified plaque.

References: - Tokyo/JP
Fig. 2-2: Attenuated plaque with high density area on 64-MDCT instances of attenuated plaque (a, b: long arrows) and calcified plaque (c, d: short arrows) are demonstrated in longitudinal (a, c) and cross sectional images (b, d) with IVUS in the left anterior descending artery. Instances of attenuated plaque (e, f, g: long arrows) and calcified plaque (e, h: short arrows) are demonstrated in stretched MPR (e) and cross sectional (f-h) images with 64-MDCT in the same positions as on IVUS. The length (4 mm) of high density (e: long arrow) is smaller than the length (6 mm) of attenuated plaque on IVUS. The maximum density is 352 HU in attenuated plaque and 1127 HU in calcified plaque on enhanced CT. The high density area of attenuated plaque corresponding to the enhanced CT image is also seen in the unenhanced CT image (g). The arrow head (e) was the partial image of another calcified plaque.

References:
Fig. 3: Attenuated plaque unaccompanied with high density area on 64-MDCT
An example of attenuated plaque is demonstrated with IVUS in the left anterior descending artery in longitudinal (a: arrows) and cross sectional (b: arrows) images. A plaque unaccompanied with high density area is demonstrated in the curved MPR (c: arrow) and cross sectional (d: long arrows) image with 64-MDCT in the same position with attenuated plaque on IVUS. The arrow head (d) shows enhanced coronary lumen. The predominant density is

References: - Tokyo/JP
Fig.: 4: Comparison of CT density between attenuated plaque and calcified plaque, which are demonstrated as calcification densities. A box and whiskers plot showing ranges and quartiles. The box extends from the 25th percentile to the 75th percentile, with a line at the median. The whiskers extend above and below the box to show the highest and lowest values. The open circle indicates an outlier.

References: - Tokyo/JP
Fig. 0: 1: Attenuated plaque with high density area on 64-MDCT An instance of attenuated plaque is demonstrated in longitudinal (a) and cross sectional images (b) with IVUS in the right coronary artery. White arrows indicate the plaque positions. A plaque with linear high density is demonstrated in the same position with attenuated plaque on IVUS in the curved MPR (c) and cross sectional (d) images with 64-MDCT. The length of high density is identical to the length of attenuated plaque on IVUS. The maximum density is 280 HU in the enhanced cross sectional CT image. The arrow head (d) shows enhanced coronary lumen. The high density corresponding to this area is also seen in the unenhanced cross sectional CT image (e).

© - Tokyo/JP
Fig. 0: 2-1: Attenuated plaque with high density area on 64-MDCT Instances of attenuated plaque (a, b: long arrows) and calcified plaque (c, d: short arrows) are demonstrated in longitudinal (a, c) and cross sectional images (b, d) with IVUS in the left anterior descending artery. Instances of attenuated plaque (e, f, g: long arrows) and calcified plaque (e, h: short arrows) are demonstrated in stretched MPR (e) and cross sectional (f-h) images with 64-MDCT in the same positions as on IVUS. The length (4 mm) of high density (e: long arrow) is smaller than the length (6 mm) of attenuated plaque on IVUS. The maximum density is 352 HU in attenuated plaque and 1127 HU in calcified plaque on enhanced CT. The high density area of attenuated plaque corresponding to the enhanced CT image is also seen in the unenhanced CT image (g). The arrow head (e) was the partial image of another calcified plaque.

© - Tokyo/JP
Fig. 0: 2-2: Attenuated plaque with high density area on 64-MDCT. Instances of attenuated plaque (a, b: long arrows) and calcified plaque (c, d: short arrows) are demonstrated in longitudinal (a, c) and cross sectional images (b, d) with IVUS in the left anterior descending artery. Instances of attenuated plaque (e, f, g: long arrows) and calcified plaque (e, h: short arrows) are demonstrated in stretched MPR (e) and cross sectional (f-h) images with 64-MDCT in the same positions as on IVUS. The length (4 mm) of high density (e: long arrow) is smaller than the length (6 mm) of attenuated plaque on IVUS. The maximum density is 352 HU in attenuated plaque and 1127 HU in calcified plaque on enhanced CT. The high density area of attenuated plaque corresponding to the enhanced CT image is also seen in the unenhanced CT image (g). The arrow head (e) was the partial image of another calcified plaque.

© - Tokyo/JP
Fig. 0: 3: Attenuated plaque unaccompanied with high density area on 64-MDCT An example of attenuated plaque is demonstrated with IVUS in the left anterior descending artery in longitudinal (a: arrows) and cross sectional (b: arrows) images. A plaque unaccompanied with high density area is demonstrated in the curved MPR (c: arrow) and cross sectional (d: long arrows) image with 64-MDCT in the same position with attenuated plaque on IVUS. The arrow head (d) shows enhanced coronary lumen. The predominant density is
Fig. 0: 4: Comparison of CT density between attenuated plaque and calcified plaque, which are demonstrated as calcification densities. A box and whiskers plot showing ranges and quartiles. The box extends from the 25th percentile to the 75th percentile, with a line at the median. The whiskers extend above and below the box to show the highest and lowest values. The open circle indicates an outlier.

© - Tokyo/JP
Conclusion

On MDCT, Attenuated plaque include low density are (<30HU), frequently accompanied with high density area whose density was significantly lower than that of calcified plaque. MDCT therefore would show promise as a noninvasive approach before PCI procedures in detecting attenuated plaque based on the difference in density values.
References


