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The Site of Plaque Rupture in Native Coronary Arteries

A Three-Vessel Intravascular Ultrasound Analysis

Myeong-Ki Hong, MD,* Gary S. Mintz, MD, FACC,‡ Cheol Whan Lee, MD,* Bong-Ki Lee, MD,* Tae-Hyun Yang, MD,* Young-Hak Kim, MD,* Jong-Min Song, MD,* Ki-Hoon Han, MD,* Duk-Hyun Kang, MD,* Sang-Sig Cheong, MD,† Jae-Kwan Song, MD, FACC,* Jae-Joong Kim, MD,* Seong-Wook Park, MD, FACC,* Seung-Jung Park, MD, FACC*

GangNeung and Seoul, Korea; and New York, New York

OBJECTIVES We evaluated the axial location of plaque ruptures in native coronary arteries.

BACKGROUND It is clinically important to understand the potential sites of plaque rupture.

METHODS We performed three-vessel intravascular ultrasound (IVUS) examination in 392 patients; 231 had acute coronary syndrome (ACS) and 161 had stable angina pectoris (SAP). The IVUS detected plaque ruptures in 206 patients: 158 ACS patients and 48 SAP patients. The distance between each coronary plaque rupture segment and the respective coronary ostium was measured with motorized IVUS transducer pullback in all three coronary arteries.

RESULTS There were a total of 273 plaque ruptures in these 206 patients; 143 in the left anterior descending artery (LAD), 40 in the left circumflex artery (LCX), and 90 in the right coronary artery (RCA). There were 67 plaque ruptures in SAP patients and 206 in ACS patients; there were 197 culprit/target lesion plaque ruptures and 76 non-culprit/non-target lesion plaque ruptures. The LAD plaque ruptures were predominantly located between 10 and 40 mm from the LAD ostium (83%, 119 of 143). The LCX plaque ruptures were evenly distributed in the entire LCX tree. Most RCA plaque ruptures were located in segments between 10 and 40 mm (48%, 43 of 90) and in segments >70 mm from the ostium (32%, 29 of 90).

CONCLUSIONS Three-vessel IVUS imaging showed that plaque ruptures occurred mainly in proximal segments of the LAD (83% of LAD plaque rupture), the proximal and distal segments of the RCA (48% and 32% of RCA plaque ruptures, respectively), and the entire LCX. (J Am Coll Cardiol 2005;46:261–5) © 2005 by the American College of Cardiology Foundation

Recent angiographic study showed that acute coronary occlusion leading to ST-segment elevation myocardial infarction (MI) tended to cluster within the proximal third of each of the coronary arteries (1). Not all acute coronary occlusions are the result of plaque rupture, however; some are the result of plaque erosion (2,3). And not all plaque ruptures lead to thrombosis and acute occlusion (3,4). The current study used intravascular ultrasound (IVUS) to evaluate the predilection site of culprit and non-culprit plaque rupture in all three native coronary arteries in patients with and without acute coronary syndrome (ACS).

METHODS

Study population. A prospective, but nonconsecutive series of 392 patients who were scheduled for coronary intervention underwent three-vessel IVUS examination. Two hundred thirty-one had ACS and 161 had stable angina pectoris (SAP). The frequency of culprit and non-culprit lesion plaque rupture in the first 235 patients undergoing three-vessel IVUS imaging was previously reported (5). Definitions of acute MI and SAP, identification of culprit/target lesions, and exclusion criteria for three-vessel IVUS imaging were described previously (5). At least one IVUS-detectable plaque rupture was present in 206 of the overall cohort of 392 patients. Among the 206 patients with at least one IVUS-detectable plaque rupture, there were 158 ACS patients (including 99 ST-segment elevation MI, 37 non–ST-segment elevation MI, and 22 Braunwald classification IIIB ACS patients) and 48 SAP patients. All patients provided written informed consent, and approval of the ethics committee was obtained.

IVUS imaging and analysis. The IVUS examinations of all three major epicardial arteries were performed before intervention and after intra-coronary administration of 0.2 mg nitroglycerin with motorized transducer pullback system (0.5 mm/s) and a commercial scanner (Boston Scientific Corp./SCIMED, Natick, Massachusetts) consisting of a rotating 30 MHz transducer within a 3.2-F imaging sheath. After successful pre-interventional imaging and treatment of the culprit/target lesion, pre-intervention IVUS exami-

From the Department of Medicine, University of Ulsan College of Medicine, Asan Medical Center, *Seoul and †GangNeung, Korea; and the ‡Cardiovascular Research Foundation, New York, New York. This study was partly supported by the Cardiovascular Research Foundation, Seoul, Korea, and a grant from the Korea Health 21 R&D Project, Ministry of Health and Welfare, Korea (0412-CR02-0704-0001).

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Abbreviations and Acronyms

ACS = acute coronary syndrome
CSA = cross-sectional area
EEM = external elastic membrane
IVUS = intravascular ultrasound
LAD = left anterior descending artery
LCX = left circumflex artery
MI = myocardial infarction
RCA = right coronary artery
SAP = stable angina pectoris

nations of the remaining non-culprit/non-target arteries and lesions were performed before any additional treatment.

Qualitative and quantitative analyses were performed according to criteria of the Clinical Expert Consensus Document on IVUS (6).

The IVUS criteria for plaque rupture were a plaque containing a cavity that communicated with the lumen with an overlying residual fibrous cap fragment (7). A typical example of plaque rupture is shown in Figure 1. The diagnosis of plaque rupture required independent review and agreement by two of the authors (M-K.H. and Y-H.K.). Confirmation of the initial 279 plaque ruptures by a second reader and repeat evaluation by the first reader resulted in 6 plaque ruptures being excluded from this study.

In all three coronary arteries in each of the patients studied, the transducer was advanced into the distal coronary artery; and an imaging run was performed back to the aorto-ostial junction. With motorized transducer pullback, we measured the distance from each plaque rupture back to the respective coronary ostium (pullback speed multiplied by number of seconds).

Quantitative IVUS analysis was performed with computerized planimetry at the plaque rupture site. Quantitative measurements included external elastic membrane and lumen cross-sectional area (CSA). The intraplaque cavity CSA was measured (8).

Statistical analysis. Statistical analysis was performed with SPSS program (SPSS Inc., Chicago, Illinois). Data are presented as frequencies or mean ± 1 SD. Comparison was performed with unpaired Student *t* test and chi-square test. A p value <0.05 was considered statistically significant.

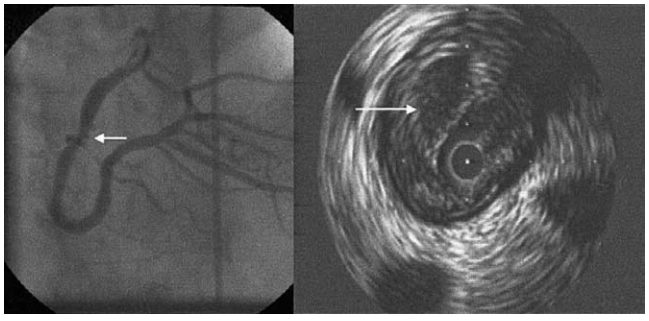

Figure 1. Angiographic and intravascular ultrasound image of a typical ruptured plaque **(arrow)** in a right coronary artery are shown.

Table 1. Baseline Clinical Characteristics of 206 Patients

Age (yrs)	57 ± 10
Male gender	170 (83%)
Hypertension	84 (41%)
Diabetes mellitus	43 (21%)
Cigarette smoking	100 (49%)
Hypercholesterolemia (total cholesterol ≥220 mg/dl)	34 (17%)
Number of diseased vessels	
1	94 (46%)
2	68 (33%)
3	44 (21%)

RESULTS

Baseline clinical characteristics of the 206 patients are shown in Table 1. Multiple plaque ruptures (≥2 plaque ruptures) were observed in 53 patients (40 ACS patients and 13 SAP patients). Thus, a total of 273 plaque ruptures were detected in 247 coronary arteries: 143 ruptures in 128 left anterior descending arteries (LAD), 40 ruptures in 38 left circumflex arteries (LCX), and 90 ruptures in 81 right coronary arteries (RCA) (Fig. 2). In these 247 arteries with at least one plaque rupture, the total length of the coronary artery imaged by IVUS was 83 ± 14 mm in the LAD, 77 ± 12 mm in the LCX, and 101 ± 22 mm in the RCA.

As illustrated in Figure 3, at least the proximal 50 mm of each of the three arteries was imaged in each patient. The frequency of plaque ruptures located in segments 0 to 30 mm, 30 to 60 mm, 60 to 90 mm, and >90 mm from the coronary ostium *when these corresponding segments were actually imaged* (thereby, excluding segments that could not be reached with the IVUS catheter) were 61% (150 of 247), 35% (86 of 247), 13% (29 of 233), and 8% (8 of 102), respectively ($p<0.001$).

A LAD plaque rupture was predominantly located in the segment between 10 and 40 mm from the LAD ostium (83%, 119 of 143). The LCX plaque ruptures were evenly distributed throughout the length of the LCX that was imaged. Most RCA plaque ruptures were located in the

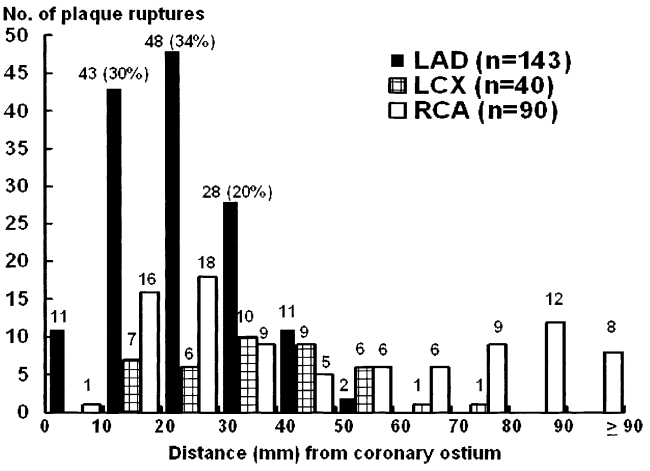

Figure 2. The frequency of 273 plaque ruptures according to distance from each coronary ostium is shown for the left anterior descending artery (LAD), left circumflex artery (LCX), and right coronary artery (RCA).