Clinical Research

Is imaging the left main able to rule out severe LAD stenosis?

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Background The 5-year cardiac mortality rate has been reported to be more than 50% in patients with left main coronary artery (LMCA) stenosis. The purpose of this study was to visualize the LMCA using intravascular ultrasound in patients who undergo interventions of the left anterior descending coronary artery (LAD). This was done in order to see the incidence and severity of plaque formation in the LMCA in patients with severe LAD stenosis, and to address if scanning LMCA is able to rule out LAD significant stenosis or vice versa. Methods A total of 293 patients with intervention of the LAD stenosis were examined with intravascular ultrasound (IVUS). The images of 278 patients were suitable for analysis. Results Fifty-three (19%) were found to have angiographic lumen reduction in the LMCA ranging from 11% to 35% (19 ± 8%). Sixty-one patients were found to have native calcification in the LMCA. Atherosclerotic plaques in LMCA were detected in 211/278 (76%) patients, of which 164/211 (78%) were eccentric, and 51/211 (24%) had calcium deposit. The cross-sectional plaque area ranged from 1.5 mm² to 21 mm² (8.4 ± 4.7 mm²). Area of stenosis was 34 ± 14% (8-66%) and diameter of stenosis was 21 ± 8% (7-42%). A weak relationship concerning severity of stenosis between LAD stenosis and LMCA stenosis was found in 59 patients with pre-interventional IVUS examinations (r = 0.47, P < 0.05 ). Conclusions LMCA is frequently involved with atherosclerotic lesions in patients with severe LAD stenosis. A weak relationship does exist concerning the severity of stenosis between LAD and LMCA. However, IVUS for LMCA lesion is not able to rule out LAD stenosis. (J Geriatr Cardiol 2004;1;35-39.)

Key Words left main coronary artery; intravascular ultrasound; coronary angiography

Left main coronary artery (LMCA) disease is highly risky because the LMCA supplies branches to most of the left ventricle. The 5-year cardiac mortality rate was reported to be more than 50%.1,2 Studies have shown that the clinical outcome has been improved significantly when this subgroup of patients is treated surgically.3-7 Hence, early detection of the left main stenosis is very important in patient management and to improve prognosis. Coronary angiography, a contour technique, has limitations in the detection of the left main coronary artery disease especially ostium disease. Intravascular ultrasound (IVUS) provides cross-sectional images of coronary arteries in a high resolution.8-10 Recent IVUS studies have shown that LMCA stenosis exists in a considerable proportion of patients with normal coronary angiograms or ambiguous coronary angiograms.11 Because the atherosclerotic process that results in coronary artery disease is a generalized process that may involve the entire vasculature, studies using transesophageal echocardiography have demonstrated that a close correlation exists between aortic plaque formation and coronary disease.12-21 Whether left main coronary artery scanning is able to diagnose coronary disease or vice versa remains unknown. The purpose of the study was to visualize the left main coronary artery using intravascular ultrasound in patients undergoing interventions of the left anterior descending coronary artery (LAD). This was done in order to see the incidence and severity of plaque formation in patients with severe LAD stenosis, and to address if LMCA scanning is able to rule out significant stenosis of LAD or vice versa.

Patients and methods

Patients

In our cardiovascular catheterization laboratories, 293 consecutive patients (243 males, mean age 54.3 ±
were performed (PTCA for 87 patients, stent for 185 patients, rotational atherectomy for 13 patients; directional coronary atherectomy for 5 patients; laser atherectomy for 4 patients). IVUS was performed following intervention in all patients and in 59 patients also before intervention. All patients provided written informed consent for IVUS examination. ECG, exercise ECG, and thallium scintigraphy were also performed.

**Coronary angiography**

Siemens HICOR biplane catheterization equipment was used for coronary angiography (Siemens, Erlangen, Germany). A bolus intracoronary injection of 0.2 mg nitroglycerin was administered before angiography, and at least 4 projections were performed. All the angiograms were stored on CD-ROM. Coronary angiograms were assessed by two operators during the procedure and documented on hard copies.

**IVUS device**

The IVUS imaging system used in this study has previously been described in detail. A 3.5F or 3.2F imaging catheter with a single 20 MHz or 30 MHz element transducer at the tip (Sonicath or Microview, Boston Scientific Co., Natick, MA) was used. The transducer is mechanically rotated within the catheter at 600 to 800 rpm to provide cross-sectional images via an ultrasound diagnostic imaging console (CVIS, Bonston Scientific Co., Natick, or Hewlett Packard, Sonos Intravascular, Andover). The images were stored on 1/2 inch s-VHS videotape for off-line analysis. An ECG was recorded simultaneously.

**Procedures**

Each IVUS study was carried out according to the standard procedure. The IVUS catheter was advanced through a guiding catheter that was used for coronary intervention under the guidance of a guide wire (0.014 inch for PTCA and stent, 0.009 inch for rotational atherectomy) in a mono-rail fashion into the left coronary artery. The catheter was advanced as far as possible into the left anterior descending (LAD) coronary artery. Serial cross-sectional images of the vessel were obtained by motorized pullback of the IVUS catheter. A second manual pullback was performed with stop frames at 2-3 mm intervals. The position of the IVUS probe was documented on X-ray film at every stop frame in order to have precise matching between the numbered IVUS images and the angiograms.

**IVUS image analysis**

The IVUS images were reviewed. Those of the LMCA were taken over the entire length between the ostium of the left coronary artery and the bifurcation of the left anterior descending and circumflex arteries. A coronary segment with a regular lumen and without intima thickening was considered normal while a segment showing concentric or eccentric atherosclerotic plaque was regarded as diseased.\(^8,11\) Plaque was defined as a concentric or eccentric echo-reflecting zone delimited internally by the lumen and externally by the echolucent area containing the media. Optimal images at the end-diastole were selected for analysis using the HP Sonos Intravascular built-in software.

The cross-sectional area of a vessel was defined as the area inside the echo-dense perimeter of the adventitia, including lumen area and plaque area.\(^11\) The lumen area was determined using planimetry of the ultrasound leading-edge interface between lumen and plaque. If there was no plaque, the lumen area was equal to the vessel area. The maximal and minimal diameter of the lumen were measured and the percentage of stenosis area and diameter were calculated.

**Statistics**

All the measurements and calculations were analyzed through the Microsoft Excel Statistics Program. All the data were expressed as mean ± SD. A student t test analysis was used to assess the vessel area difference between the two groups described below. Differences were considered to be statistically significant at a P value less than 0.05. Correction between continuous variables was assessed using linear regression.

**Results**

The IVUS images were reviewed in 293 patients. Six patients had separated LAD and left circumflex (LCx) origin and were excluded from the analysis. The IVUS images of nine patients were not suitable for analysis due to either non-uniform rotation of the IVUS catheter or bad image quality. A total of 278 LMCA were analyzed. Of the 59 patients who were examined pre-and post-interventionally, reproducibility was assessed by measuring the plaque area and the percentage of stenosis in LMCA \(r = 0.95, \text{SEE} = \pm 1.29 \text{mm}^2, P < 0.001\) for plaque area; \(r = 0.91, \text{SEE} = \pm 5.5\%, P < 0.001\), for the percentage of stenosis).

**Angiographic assessment**

Of the 278 patients, 53 (19%) were found to have angiographic luminal reduction in the LMCA ranging from 11% to 35% (19 ± 8%). Sixty-one patients were found
to have native calcification in the LMCA.

**IVUS assessment**

Atherosclerotic plaques in LMCA were detected in 211/278 (76%) patients, of which 164/211 (78%) were eccentric, and 51/211 (24%) had calcium deposit (Fig. 1). The cross-sectional plaque ranged from 1.5 mm² to 21 mm² (8.4 ± 4.7 mm²).

![Fig. 1. Comparison of coronary angiogram and intravascular ultrasound images in the proximal LAD and the left main coronary artery. A concentric soft plaque at the LAD stenotic segment was found. An eccentric calcified plaque with acoustic shadowing which results in an area stenosis of 36% can be seen by IVUS.](image)

Area stenosis was 34 ± 14% (8-66%); diameter stenosis was 21 ± 8% (7-42%). In the other 67 patients (24%), no lesions were detected even though severe LAD stenoses did exist (Fig. 2).

A weak relationship concerning severity of stenosis between LAD stenosis and LMCA stenosis was found in the 59 patients with pre-interventional IVUS examinations (r = 0.47, P < 0.05).

**Discussion**

Recent studies suggest that imaging of the left main coronary artery might be useful in ruling out distal LAD stenosis and attempts have been made to assess morphology and physiology of the coronary artery noninvasively by transesophageal echocardiography (TEE). Since coronary artery disease is to a certain extent a diffusive disease, a non-diseased proximal segment of an artery might be associated with a mildly diseased distal segment. Accurate identification of the degree of LMCA narrowing is of paramount importance. Interpretation of the angiographic appearance of the LMCA and proximal LAD is subject not only to problems that complicate coronary angiography in general, but also to specific problems deriving from the special anatomy of the LMCA and proximal LAD. Angiography is a relatively insensitive diagnostic tool especially in the early stages of coronary artery disease. It often underestimates the severity and extent of atherosclerotic lesions.

Quantitative histologic examination of the coronary arteries at autopsy has indicated that two morphologic features in particular account for the tendency to underestimate degrees of arterial narrowing. The coronary atherosclerotic process is diffuse, rather than focal, and the residual nonoccluded lumen is usually eccentric in location.

There have been several preliminary reports documenting the feasibility of visualizing proximal coronary arteries by two-dimensional transesophageal echocardiography. Also attempts have been made to identify the left main coronary artery stenosis with this technique, and the detection rate has varied from 65% in one series to 100% in a small group of 4 patients. In another study, transesophageal echocardiography identified LAD stenosis in 5 of 7 (71%) patients. Sandrash and co-workers showed that in a relatively large number of patients, transesophageal echocardiography identified the left main coronary artery stenosis with a high degree of accuracy, however the technique was less useful in the detection of stenotic lesions in the proximal LAD.
Diffuse narrowing forces the angiographer to compare that the focus may be less, but still severely narrowed. Intravascular ultrasound enables accurate determination of vessel dimensions and wall characteristics and is more sensitive in delineating early intimal changes than angiography. Several methods have been tried to assess LMCA disease because of the importance of the diagnosis.

Angiographic diagnosis and documentation of LMCA/ proximal LAD stenosis are impeded by foreshortening and superimposition on other branches and require special projections. Detection of LMCA disease by thoracic and transesophageal echocardiography has been reported, but in comparison with angiography the image resolution is too low to obtain accurate quantification. IVUS has been recognized as the most accurate method available for measuring the vessel wall and the vessel lumen in living subjects. IVUS provides high resolution images that can be matched reliably with longitudinal angiographic image, and allows for quantification of cross-sectional stenosis. Isolated LMCA lesion is rarely seen. Severe and diffuse coronary atherosclerosis usually exists once marked stenosis is found in LMCA.

In the present study, we have demonstrated that LMCA is frequently involved with atherosclerotic lesions in patients with severe LAD stenosis. In addition, we also found that a relationship does exist concerning the severity of stenosis between LAD and LMCA. However, we have demonstrated that there is a considerable proportion of patients without LMCA involvement even though severe LAD stenosis exists. Therefore, the scanning of LMCA does not rule out LAD stenosis. There are large discrepancies between the severity of stenosis and the presence of LMCA lesions. The detection of LMCA disease to any extent by TEE or MRI suggests further diagnostic work-up such as coronary angiography with IVUS; however, the detection of a disease-free LMCA may still be consistent with severe disease at the distal coronary artery. In patients with suspected LMCA disease, problems of diffuse narrowing, eccentric, slit-like lumens, shortening and varying courses of the LMCA make the routine use of IVUS critical.

References