Correlation between the Carotid Intima-Media Thickness and the Plaque Burden of the Left Main Coronary Artery Using Ultrasonography

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ABSTRACT

Background and Objectives: It has been reported that the common carotid artery (CCA) intima-media thickness (IMT) correlates to angiographically determined coronary artery stenosis. The aim of this study was to evaluate the correlation between the carotid IMT and left main (LM) plaque using ultrasonography. Subjects and Methods: In fifty patients (mean age 59.6±9.9, males 35 (70%)) with coronary artery disease (CAD), the risk factors of atherosclerosis were evaluated and coronary angiographs obtained. The carotid IMT was measured in the far wall of both CCA, with a 10 MHz linear probe, and the value of the IMT was automatically calculated using programmed software (M’ATH, METRIS Co., Argenteuil, France). The LM plaque was measured by intravascular ultrasound. The maximal thickness, ratio of the maximal thickness, cross-sectional area (CSA) and burden of the plaque were measured at 2 mm intervals, and the average values calculated. Results: In the right common carotid artery, the maximal IMT significantly correlated with the mean plaque CSA and plaque burden of the LM (r=0.375, p=0.007, r=0.408, p=0.003, respectively). The mean IMT significantly correlated with the plaque burden of the LM, but not with the mean plaque CSA of the LM (r=0.357, p=0.011, r=0.264, p=0.063, respectively). In the left common carotid artery, the maximal IMT was not significantly correlated with the mean plaque CSA and plaque burden of the LM (p=0.251, p=0.218, respectively). The mean IMT was not correlated with the mean plaque CSA and plaque burden of the LM (p=0.249, p=0.078, respectively). Conclusion: There was a significant correlation between the right CCA IMT and plaque burden of the LM in patients with CAD.

KEY WORDS: Ultrasound; Coronary disease; Carotid arteries.

Introduction

The ultrasonographic assessment of peripheral arteries has evolved as a promising technique for non-invasive evaluation of atherosclerosis. Assessment of the carotid artery intima-media thickness (IMT), using B-mode ultrasound, is a useful clinical and research tool for the measurement of atherosclerosis. An increased IMT is considered as a sign of early atherosclerosis of the carotid artery, and is associated with future cardiovascular events, asymptomatic myocardial ischemia, coronary risk factors and a change in the coronary risk factors after therapeutic intervention. The effect of the IMT of the carotid artery has been used as the primary variable in the evaluation of the progression/regression of atherosclerosis during lipid-lowering or antihypertensive treatment. The atherosclerotic process can be studied at an earlier phase through measurement of the carotid IMT. Determination of the carotid IMT allows for a direct, non-invasive, repeatable measurement. It has been reported that the common carotid IMT is correlated to the angiographically determined coronary artery stenosis in coronary angiography, this correlation is only weak. In contrast to coronary angiography, which investigates the vascular contour and lumen, intravascular ultrasound (IVUS) imaging depicts the structural morphology of the arterial wall itself. Despite being angiographically silent, left main (LM) disease, as detected by IVUS, is an independent predictor of future cardiac events and may serve as a marker for such events. The aim of this study was to evaluate the correlation between the carotid IMT and the plaque burden of the left main coronary artery (LM),
using B-mode ultrasound and IVUS, respectively.

Subjects and Methods

Study population
Fifty consecutive patients with ischemic heart disease, undergoing percutaneous coronary intervention on the left anterior descending or left circumflex artery, were enrolled. All had angiographically normal or mild LM disease by visual assessment (<20% diameter stenosis). The diagnosis of stable angina was defined as a clinically constant pattern of severity for more than two months. Unstable angina was diagnosed if the patient’s chest pain, which was accompanied by ST-T changes, was either new or worse in frequency, severity or duration, superimposed on a pre-existing pattern of anginal pain. Patients were diagnosed as having myocardial infarction according to the presence of chest pain lasting more than 30 minutes, accompanied by ST-T segment elevation in two or more related electrocardiographic leads, pathologic Q waves, or elevation of serum levels of creatine kinase-MB fraction (CK-MB) (more than twice the upper normal limit) or cardiac troponin-I. Hypertension was defined as a blood pressure \( \geq 140/90 \text{ mmHg} \) or the use of anti-hypertensive medications. Diabetes was defined as being present when previously diagnosed by a physician. Smoking was estimated from the patient’s history. Hypercholesterolemia was defined as a total-cholesterol level of \( \geq 200 \text{ mg/dL} \). Obesity was defined as a body mass index (BMI) (weight in kilograms divided by the square of the height in meters) of \( \geq 25 \).

Measurement of the carotid IMT
B-mode ultrasound measurements were performed with a 10-MHz linear-array transducer, connected to a Vivid 7 echocardiograph (General Electronics Corp., Horten, Norway). The patients were examined in the supine position. The operator directed the sound beam perpendicularly to the arterial surface of the far wall of the common carotid artery (CCA) to obtain two parallel echogenic lines, corresponding to the blood-intima and media-adventitia interfaces. The right and left CCA IMT were measured at least 10 mm proximal to the bifurcation. The values of the maximal and mean IMT were automatically calculated by the programmed software (M’ATH, METRIS Co., Argenteuil, France) (Fig. 1). The presence of a plaque was evaluated in the carotid artery. The plaque was defined as a distinct ring sites, so an IMT \( > 1.3 \text{ mm} \) was consequently not included in the calculation of the carotid IMT.

Measurement of the LM plaque and coronary angiography
Coronary angiography was performed using the standard Judkins technique, and significant coronary artery stenosis was diagnosed when the coronary angiogram showed a \( \geq 50\% \) reduction in the lumen diameter. The LM plaque was measured using IVUS (CLEARVIEW, Boston Scientific Corp., San Jose, California, USA), with a 30 MHz probe, at 2 mm intervals. In each cross section, the maximal thickness, ratio of thickness, cross-sectional area (CSA) and burden of the LM plaque were measured. These variables were calculated by the following formulae: ratio of the thickness=\((\text{maximal plaque thickness/vessel diameter})\times100\), plaque CSA =vessel CSA-lumen CSA, plaque burden=\((\text{plaque CSA/vessel CSA})\times100\) (Fig. 2). For each variable the...
average value was calculated.

**Statistical analysis**

All results were expressed as the mean ± standard error of the mean. SPSS 11.0 was used for all statistical calculations. Statistical comparisons were performed using Student’s t-tests. Correlations between the variables of the carotid IMT and plaque of the LM were evaluated using the Pearson correlation coefficient. A probability value of <0.05 was taken as statistically significant. Multiple linear regression analysis was used to test for an association between the plaque burden of the LM and male, hypertension, diabetes, smoking, hypercholesterolemia, obesity and the mean right CCA IMT.

**Results**

**Baseline characteristics**

The mean age of the patients in this study was 59.6 ± 9.9 years; 70% were male. The diagnoses of the patients were 16 (32%) with stable angina, 10 (20%) with unstable angina and 24 (48%) with myocardial infarction. Hypertension was present in 20 (40%), diabetes mellitus in 9 (18%), smoking in 27 (54%), hypercholesterolemia in 15 (30%) and obesity in 16 (32%) of the patients.

Twenty-seven patients (54%) had a one-vessel disease, 17 (34%) a two-vessel disease and 6 (12%) a three-vessel disease (Table 1).

**Effect of the risk factors for carotid IMT and LM plaque**

With regard to a difference between the genders, the plaque CSA and burden of the LM were 10.9 ± 4.2 mm², 40.9 ± 12.0% in males and 8.2 ± 1.7 mm², 32.9 ± 6.9% in females, respectively. The plaque CSA and burden were significantly larger in the males compared to those in the females (p<0.023, p=0.019). In the hypertensive and normotensive patients, the right maximal and mean carotid IMTs were 1.04 ± 0.17 and 0.82 ± 0.14 mm, and 0.91 ± 0.14 and 0.71 ± 0.11 mm, respectively. The right maximal and mean carotid IMT were larger in the hypertensive than normotensive patients (p=0.005, p=0.006). For diabetes mellitus, there was no significant difference between the patients with and those without in the carotid IMT and plaque of the LM (Table 2A). For smoking, the maximal thickness, ratio of the thickness, CSA and burden of the LM plaque were 1.67 ± 0.56 mm, 23.3 ± 7.5%, 11.5 ± 4.4 mm² and 43.4 ± 11.9%, respectively, in the smokers and 1.17 ± 0.29 mm, 16.9 ± 5.4%, 8.4 ± 2.0 mm² and 32.8 ± 7.2%, respectively, in the non-smokers. The maximal thickness, ratio of the thickness, CSA and burden of the plaque were larger in the smokers than in the nonsmokers (p=0.000, p=0.002, p=0.003 and p=0.000, respectively) (Table 2B). In a multiple linear regression analysis, the plaque burden of the LM was significantly associated with smoking and the right mean CCA IMT (p=0.042, p=0.029, respectively) (Table 3).

**Plaque of the LM related to the presence or absence of carotid plaque**

A carotid plaque was present in 14 (28%) patients;
Determination of the IMT was objective and the points of measurement were poor in faces. There are many different methods for measuring the IMT, including ultrasound, IVUS, and clinical examination. Our study in [10] investigated the correlations between coronary atherosclerosis, as and carotid atherosclerosis, as detected by IVUS and ultrasonography, respectively.

The IMT was defined as the maximum measurement determined at the far wall between the leading edges of the lumen-intima and the media-adventitia interfaces. There are many different methods for measuring the carotid IMT. In previous studies, measurement of the IMT was subjective as the operator and the points of measurement were poor (less than 10 points). We calculated the mean IMT automatically using programmed software (MATH, METRIS Co., Argenteuil, France) (Fig. 1). Thus, the measurement of the IMT was objective and the points of measurement were poor.
measurement were larger (more than 100 points) than in previous studies.

Carotid plaques are related to the risk of cardiovascular death or myocardial infarction. Kato et al.\(^5\) reported that the prevalence of soft and hard plaques was higher in the patients with multiple coronary plaques than in those with single plaques. In ACS, they demonstrated that multiple coronary plaques are associated with positive carotid remodeling. Honda et al.\(^16\) reported that echolucent carotid plaques, with low integrated backscatter values, predicted the coronary plaque complexity and development of future coronary complications in patients with stable CAD. These findings\(^9,15-17\) may suggest that carotid plaques may reflect vulnerable coronary lesions. Giral et al.\(^18\) reported that echographic evaluation of the carotid plaque significantly improved the diagnostic specificity of the exercise electrocardiography. There are usefulness in predicting CAD by ultrasonic evaluation of the carotid plaque.\(^17,18\)

In our study, carotid plaques were found in 28% of patients. The plaque burden of the LM was larger in the patient with carotid plaques than in those without (Fig. 4). This finding suggests that the evaluation of the carotid plaque appears to provide information on the diagnosis of CAD.

An increased carotid IMT is regarded as an early sign of atherosclerosis. The IMT increases if the vascular walls are exposed to cardiovascular risk factors, such as age, hypercholesterolemia, hypertension and smoking.\(^19,22\) The reduction of the cardiovascular risk factors inhibits the progression of increases in the IMT.\(^6\) Because B-mode ultrasound imaging of arterial walls is a noninvasive and "patient-friendly" technique, it allows for repeated measurements over time in large groups of patients. Therefore, the method has become a powerful tool in studies of atherosclerosis.

Coronary angiography can only indirectly measure the degree of atherosclerosis by assessing the lumen size. Therefore, coronary angiography can only quantify the atherosclerosis at a relatively later stage of invasive lesion formation. Unlike angiography, which investigates the vascular contours and lumen, ultrasound imaging depicts the structural morphology of the arterial wall itself. Despite being angiographically silent, the LM disease detected by IVUS is an independent predictor of future cardiac events, which may serve as a marker for such events.\(^13\) The LM was selected from among the coronary arteries, because the evaluation of whole segments is possible in the left main coronary artery using IVUS.

There are many studies about the relationship between coronary atherosclerosis detected angiographically and carotid atherosclerosis.\(^4-9\) Carotid IMT measurements can give a comprehensive picture of the damage caused on the arterial wall by several coronary heart disease risk factors over time\(^23\) and are an indicator of generalized atherosclerosis.\(^3\) Adams et al.\(^13\) reported that although the carotid IMT is significantly correlated with the extent and severity of coronary artery disease, the relationship is only weak. Usually, both CCAs were used to evaluate the carotid IMT.\(^7,9,12,18,20\) Some reports\(^20,26\) have described that one of the CCAs IMT was correlated with CAD, and was used to evaluate the carotid IMT. Ogata et al.\(^21\) reported that the average of the maximum CCA IMT was significantly correlated with the LM atherosclerosis evaluated by IVUS. In this study, the right carotid IMT was more correlated with the LM plaque than the left carotid IMT. It may seem that the right CCA is a shorter distance from the LM than the left CCA.

This study had some limitations; the sample size was small and the patients were a consecutive group undergoing cardiac catheterization. This selection bias means that the correlations between the carotid IMT and CAD may not be applicable to the general population.

**Conclusion**

There was a significant correlation between the right carotid IMT and plaque burden of the LM in the patient with CAD. The presence of plaques in the CCAs provides information for diagnosing CAD. These findings suggest that the evaluation of the CCA by ultra-
sound can be useful in the diagnosis of LM disease or coronary atherosclerosis.

REFERENCES