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The Functional Effects of Intramural Course of Coronary Arteries and its Relation to Coronary Atherosclerosis

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ABSTRACT

OBJECTIVES This study observed hemodynamic consequences of myocardial bridging and its relation to coronary atherosclerosis.

BACKGROUND Myocardial bridging is seen as intramural course by computed tomography angiography (CTA) or systolic compression by invasive coronary angiography. Segments with myocardial bridging are in previous studies closely associated with proximal atherosclerotic plaques.

METHODS We prospectively studied 100 patients 63 ± 7 years of age with intermediate likelihood of coronary artery disease. Segments with superficial (>1 mm) or deep (>2 mm) intramural course were identified using CTA. Myocardial perfusion was studied by 15-Oxygen water positron emission tomography and systolic compression by invasive coronary angiography.

RESULTS Myocardial bridging was detected in 34 (34%) patients in 48 different vascular segments. Of these, 24 (50%) were deep and systolic compression was present in 14 (29%). In patients without obstructive coronary artery disease, myocardial stress perfusion distal to myocardial bridging was comparable with remote control regions (3.3 ± 0.9 ml/g/min vs. 3.3 ± 0.7 ml/g/min, n = 24, p = 0.88). Stress perfusion was comparable in segments with and without systolic compression (3.0 ± 0.9 vs. 2.7 ± 1.0 ml/g/min, p = 0.43). Atherosclerotic plaques were more frequent in proximal (71%) than myocardial bridging (7%) or distal (21%) segments. The presence of atherosclerosis and the average number of plaques were comparable in coronary arteries with and without myocardial bridging (73% vs. 60%, p = 0.14 and 2.0 ± 1.7 vs. 1.5 ± 1.6, p = 0.06). Median Agatston coronary calcium score was not elevated in vessels with myocardial bridge (15 [interquartile range: 0, 129] vs. 50 [interquartile range: 0, 241], p = 0.21).

CONCLUSIONS Myocardial bridging of coronary arteries is common on CTA, but only approximately one-third of these show systolic compression. Myocardial bridging is not associated with reduced myocardial perfusion during vasodilator stress. Atherosclerosis is located predominantly proximal to myocardial bridging but atherosclerotic burden and presence of vulnerable plaques were comparable. (J Am Coll Cardiol Img 2015;8:697–704) © 2015 by the American College of Cardiology Foundation.

Myocardial bridging (MB) was originally defined in autopsies as an anatomic variation in which myocardium overlies a segment of coronary artery. Later, with a widespread use of invasive coronary angiography (ICA), MB was seen as a systolic compression of a coronary artery segment (1,2). Currently, computed tomography angiography (CTA) has enabled noninvasive imaging of

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ABBREVIATIONS AND ACRONYMS

CAD = coronary artery disease

CTA = computed tomography angiography

FFR = fractional flow reserve

ICA = invasive coronary angiography

LAD = left anterior descending

LCX = left circumflex

MB = myocardial bridging

MBF = myocardial blood flow

PET = positron emission tomography

RCA = right coronary artery

SPECT = single-photon emission computed tomography

coronary vasculature. MBs can be identified by CTA as an intramural course of coronary artery and anatomic definition of MB has re-emerged (1–4).

MB has been considered a relatively common and benign congenital variation of coronary anatomy. However, some studies and case reports have associated it with angina pectoris, depressed left ventricular function, arrhythmia and sudden death (1,2). Myocardial blood flow (MBF) occurs predominantly during diastole while coronary compression of the myocardial bridge is at systole. However, intracoronary Doppler studies have shown effects beyond systolic compression (5–8). In some of the previous clinical single-photon emission computed tomography (SPECT) studies, severe systolic compression has been associated with reversible ischemia (9–12).

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Hybrid imaging using positron emission tomography (PET) and computed tomography (CT) allows simultaneous imaging of coronary anatomy and MBF in quantitative terms by PET. To our knowledge, there are no clinical studies evaluating the effects of intramural course of coronary artery in CTA on absolute MBF. In this study, we evaluated the effects of MB defined by either anatomical (intramural course) or functional (systolic compression) criteria on absolute MBF in response to pharmacologic stress as assessed with 15-Oxygen (^{15}O) water myocardial perfusion PET. We also evaluated the relationship between MB and coronary atherosclerosis in these patients.

METHODS

STUDY POPULATION AND DESIGN. The study group consisted of 100 outpatients 63 ± 7 years of age. Patients were evaluated for stable chest pain with a 30% to 70% pre-test likelihood of coronary artery disease (CAD). Exclusion criteria were previous myocardial infarction, unstable angina pectoris, atrial fibrillation, second- or third-degree atrioventricular block, heart failure (New York Heart Association functional class IV), iodine allergy, pregnancy, severe kidney failure, and symptomatic asthma. Patients with previous CAD proven by ICA were excluded. Follow-up data on cardiac events was obtained from national health statistics. The study was performed according to the Declaration of Helsinki and it was approved by the local ethics committee. All individuals gave their informed written consent.

COMPUTED TOMOGRAPHY. Patients were scanned with a 64-row PET/CT scanner (GE Discovery VCT, General Electric Medical Systems, Waukesha, Wisconsin). The collimation was 64 × 0.625 mm, gantry rotation time was 350 ms, tube current was 600 to 750 mA, and voltage was 100 to 120 kV, depending on patient size. Patients received 800 ug sublingual nitrate before the scan. Intravenous metoprolol 0 to 30 mg was administered before the scan to reach a target heart rate of 60 bpm. Iodinated contrast infusion (60 to 80 ml of 400 mg iodine/ml iomeprol at 4 to 4.5 ml/s) was followed by a saline flush.

POSITRON EMISSION TOMOGRAPHY. PET studies were performed after an overnight fast. Alcohol and caffeine were prohibited 12 h before the study. Rest-stress perfusion cardiac PET was performed immediately after CT and ^{15}O-labeled water (900 to 1100 MBq) was injected (RadiowaterGenerator, Hidex Oy, Turku, Finland) at rest as an intravenous bolus over 15 s. A dynamic acquisition of the heart was performed (14 × 5 s, 3 × 10 s, 3 × 20 s, and 4 × 30 s), after which an adenosine-induced stress scan was performed. Adenosine infusion was started 2 min before the scan and continued at the rate of 140 μg/kg/min until the scan was completed. The values of MBF were expressed as ml/g/min. The details are described in our previous study (13).

INVASIVE CORONARY ANGIOGRAPHY. All patients underwent ICA performed with Siemens Axiom Artis coronary angiography system (Siemens, Erlangen, Germany). Quantitative analysis of coronary angiograms (Quantcore, Siemens) for CAD and assessment for systolic compression was performed by an experienced reader. A 17-segment standard model was used (14).

PET/CT IMAGE ANALYSIS AND INTERPRETATION. CTA images were analyzed according to the standard 17-vessel segment American Heart Association model (14). To evaluate the presence of intramural course, multiplanar reconstruction images were used. The intramural course was defined as superficial (1 to 2 mm) or deep (>2 mm of overlying myocardium) according to the definitions used in the previous studies (4,15,16). PET images were analyzed with Carimas software (13). Standard polar plots and parametric volume of the heart were produced, allowing image fusion with ADW 4.4 software (CardiIQFusion, General Electric Medical Systems, Milwaukee, Wisconsin). PET/CT hybrid images were used to match coronary artery segments affected by MB to corresponding myocardial flow areas. Myocardial segments for flow analysis were chosen distal to MB and myocardial areas of other coronary branches affected