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Imaging of Coronary Artery Microstructure (In Vitro) With Optical Coherence Tomography

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In this work, we suggest the feasibility of optical coherence tomography (OCT) for intracoronary imaging of plaque morphology at a micron scale.[1] OCT was initially introduced to image the transparent tissue of the eye at a level of resolution significantly greater than conventional ultrasound, angiography, or magnetic resonance imaging.[1,2] Recently, it has been used to image nontransparent tissue.[3] OCT performs cross-sectional, micron scale, tomographic imaging and is analogous to conventional ultrasound, except that OCT measures the intensity of backreflected infrared light rather than acoustical waves. The principles of operation and imaging mechanisms have been previously described.[1,2] OCT uses low coherent infrared light (or ultrashort laser pulses) to generate tomographic images with an axial resolution between 4 and 20 μm, depending on the light source utilized. This represents an improvement of up to 25 times over intravascular ultrasound. OCT is an attractive new technology for intravascular imaging because it achieves high resolution and is based on optical fiber communications technology, which allows integration into catheters and endoscopes. We demonstrate the ability of OCT to generate images of an atherosclerotic coronary artery in vitro.

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The left anterior descending coronary artery was removed immediately postmortem from an 83-year-old man who succumbed to an acute aortic rupture. A cross-sectional image was generated by scanning the beam across the exposed luminal surface. A visible light-guiding beam allowed precise registration of imaging planes. Corresponding histology was obtained by routine tissue processing. The wavelength of the OCT source was 1,300 nm with a bandwidth of 50 nm. This yields an axial resolution of 20 μm, which was confirmed by experimental measurement (point spread function) and is consistent with theory.[1,4] The dynamic range was 109

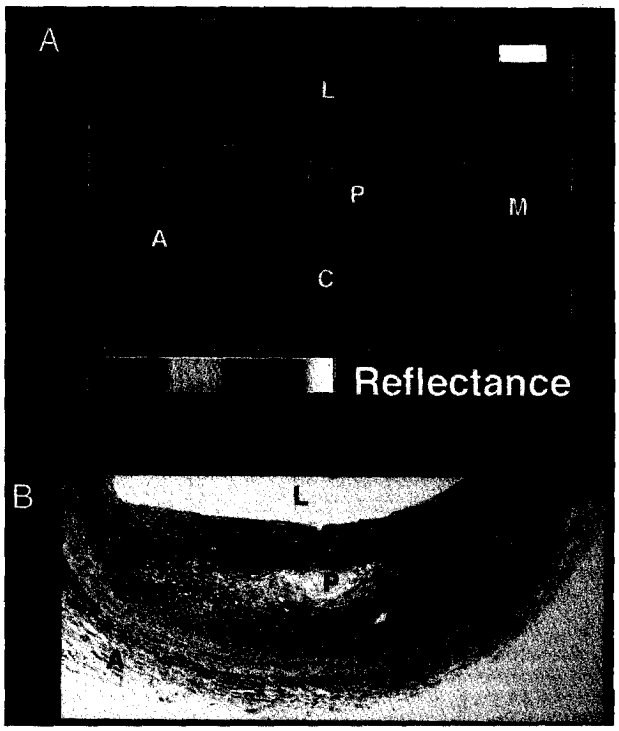

FIGURE 1. Optical coherence tomographic image of human coronary artery and corresponding histology. The image of the coronary artery is shown in false color. Penetration through the artery to the underlying coverslip (C) is seen. The adventitia (A), media (M), intima and lumen (L) are well demarcated. In addition, a small lipid-filled plaque (P) is seen. The *bar* represents 500 μm.

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dB, using a power of 160 μW at the sample. The image size was 500 (transverse) by 250 pixels (longitudinal). The acquisition time for the image was 40 seconds.

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The image (Figure 1) suggests a feasibility of OCT for intravascular high-resolution diagnostics. Structural details are delineated with a level of resolution (20 μm) and dynamic range (109 dB) not possible using other imaging modalities. Further investigations will focus on reducing acquisition times, imaging in vivo, improving resolution, and imaging through blood. The major limitation of the system used here is the acquisition time of 40 seconds. This is inadequate for in vivo imaging, but modifications of system design including using higher power optical sources and higher speed scanning techniques should provide real-time imaging. Because OCT technology uses optical fibers, it can be readily integrated into intravascular catheters in a manner similar to that used for intravascular ultrasound. Spatial resolution may be improved to the level of approximately 4 μm by using alternate light sources such as solid-state lasers.[5] Finally, although this image was performed in saline solution (which is optically transparent), preliminary studies suggest that imaging may be performed through varying depths of blood, as may be encountered in an intravascular application. Although blood strongly absorbs light at visible wavelengths, it is relatively nonabsorbing at near infrared wavelengths which are used for imaging. Further investigations are needed to quantitatively address this issue. However, if imaging through blood significantly reduces diagnostic information, simultaneous injections of saline solution can be performed in vivo.

OCT achieves high-resolution and image differentiation of vascular tissues to a degree that has not been previously possible with any method except excisional biopsy. Thus, OCT represents a promising new diagnostic technology for intracoronary imaging, which could permit the in vivo evaluation of critical vascular pathology.

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Reduction in Left Ventricular Mass in Patients With Systemic Hypertension Treated With *Enalapril, Lisinopril, or Fosenopril*

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Left ventricular (LV) hypertrophy is a pathophysiologic adaptation to increased afterload.[1] However, the Framingham cohort and other studies have identified LV hypertrophy as an independent risk factor for congestive heart failure, coronary artery disease, and sudden death.[2–5] There are no data demonstrating reduced risk associated with pharmacologically reduced LV mass. Moreover, there are few functional data associated with diminished ventricular mass in which a variety of agents within a class may be compared. Demonstration of preserved function after diminution of mass is vital. The angiotensin-converting enzyme (ACE) inhibitors are known to decrease LV mass.[6,7] This study examines which hemodynamic or humoral factors are associated with reduced LV mass.

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Thirty patients (24 men and 6 women, 24 white and 6 black, average age 47 years [range 27 to 65]) with mild to moderate essential arterial hypertension were included in this study. No patient had a history of cerebrovascular accident, hypertensive encephalopathy, myocardial infarction, or any other significant disorder. All patients discontinued antihypertensive medication ≥4 weeks before entering the study and were treated with placebo during the last 2 weeks of the washout period. Only patients who had supine diastolic pressure 90 to 115 mm Hg on the day before active therapy were included. Pretreatment clinical evaluation included electrocardiogram, chest x-ray, complete laboratory screening, measurements of circulating catecholamines, plasma renin activity, and plasma aldosterone concentration. Systemic hemodynamic indexes were obtained by invasive techniques, and a 2-dimensional M-mode echocardiogram was recorded. Thereafter, 5 mg of enalapril, 20 mg of lisinopril, or 10 mg of fosenopril once daily were prescribed to groups of 10 patients per agent. After 2 weeks, if diastolic pressure still exceeded 90 mm Hg, the doses were doubled; after 4 weeks, either the doses were tripled or 50 mg of hydrochlorothiazide was added to therapy in 2 patients treated with enalapril.

After 12 weeks of active therapy, all hemodynamic, echocardiographic, and laboratory studies were repeated. Patients were studied in the hemodynamic laboratory after an overnight fast as previously described.[8] In brief, with use of a modified Seldinger method, the brachial artery and median antecubital vein were cannulated with polyethylene tubing advanced to shoulder

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