

Quantitative methods for the anatomic and functional assessment of a coronary stenosis

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The severity of a coronary artery obstruction (stenosis) is traditionally characterized by a visual assessment of its anatomic dimensions. These visual estimations, usually made from cineangiograms, have been shown to be fraught with error. Furthermore, a determination of the anatomic dimensions of a stenosis does not, in itself, shed light on the functional or physiologic impact of the stenosis. With the advent of digital cardiac angiography, a number of quantitative methods have been introduced for the anatomic assessment of a stenosis. This quantitative coronary arteriography (QCA) has also been applied to predictions of the functional implications of a stenosis.

This project involves the development and application of a new QCA algorithm. The algorithm, which is based on a spatial frequency (Fourier) analysis of the image pixels, primarily addresses the measurement errors caused by the linespread function of the imaging system. Measurements of computer simulated and vessel phantom images have been performed. These experiments established that the new algorithm has a lower sensitivity to the linespread function than do other commonly used QCA techniques. Additional measurements on coronary vessel phantoms, placed in vivo, have indicated that the Fourier-based algorithm is less sensitive to cardiac tissue signal variations.

Fourier anatomic measurements of implanted coronary stenoses have been applied to a prediction of the functional implications of the stenoses. Using fluid mechanical theory, the pressure drop across the stenoses was predicted and validated in vivo. In addition to the use of the new QCA algorithm, these measurements incorporated modifications to the previously investigated fluid mechanical model. The resulting precision of the measurements is shown to have improved.

This functional analysis was extended to a prediction and validation of the coronary flow reserve (CFR) in the presence of a stenosis. These measurements established the feasibility of predicting the CFR in a particular patient from QCA measurements of the stenosis dimensions. The patient-specific analysis was also applied to a determination of the flow reserve in the absence of the stenosis. This information can potentially illuminate the presence of other cardiac defects, besides the stenosis, which have remained undetected.