Association Between Three-Dimensional Geometrical Configuration of the Coronary Arteries and Plaque Characteristics Using IVUS-VH Analysis.

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Background: Vascular geometry mediates fluid dynamics and shear stress and may thereby predispose coronary arteries to atherosclerosis. However, the association between advanced three-dimensional geometrical features and vulnerability to plaque rupture has not been investigated.

Objectives: To examine the potential relationship between arterial curvature, torsion and tortuosity and indicators of plaque vulnerability using IVUS-VH (intravascular ultrasound-virtual histology).

Methods: We have evaluated 32 de-novo coronary lesions using conventional coronary angiography and used CardiOp-B package (Paieon Inc) for simple three-dimensional reconstructions. For advanced geometrical analysis we have developed a novel algorithm for high-resolution continuous-point evaluation of curvature, torsion and tortuosity, along a segment. All segments were further evaluated by IVUS-VH (Volcano Corp.). Plaque components were examined on the basis of tissue characteristics, sizes and densities of various components: Necrotic-Core (NC), Dense-Calcium (DC), Fibrotic and Fibrofattic.

Results: Several advanced geometrical features were significantly correlated with plaque vulnerability as measured by the sectional NC/DC ratio: mean and maximal curvature ($r=0.56$, $p=0.0008$; $r=0.61$, $p<0.0001$), mean and maximal torsion ($r=0.51$, $p=0.002$; $r=0.45$, $p= 0.008$), and segment tortuosity ($r=0.44$, $p= 0.011$). A trend-level correlation was found between plaque thickness and maximal torsion ($r=0.34$, $p=0.058$) and between NC thickness and median torsion ($r=0.33$, $p=0.063$). Calcium density was correlated with mean curvature and maximal torsion ($r=0.70$, $p<0.0001$; $r=0.55$, $p= 0.001$).

Conclusions: Three-dimensional geometrical features of the coronary arteries are correlated with IVUS-VH indicators of plaque vulnerability. This data provides insight into the role of mechanical stimuli in the localization of atherosclerotic plaque formation and tendency to plaque rupture. This novel algorithm should be further explored in clinical outcome studies.