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The Role of Shear Stress in Atherosclerotic Plaque Progression, Destabilization and Rupture

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Abstract: The pathophysiology of atherosclerosis is complex and multifactorial, involving systemic risk factors and biomechanical stimuli. Atherosclerotic plaques predominantly form in regions that are exposed to low shear stress of the blood at the vessel wall, whereas regions of moderate and high shear stress are generally protected. For more than 20 years, my research group performs studies to investigate the role of shear stress in atherosclerotic plaque formation and rupture in coronary and carotid arteries of patients and laboratory animals. For that reason, new technology was developed to 3D reconstruct arteries based on fusion of multiple invasive and non-invasive imaging modalities. These 3D reconstructions were used as input for computational fluid mechanics to derive the local shear stress. We noticed that if the lumen was not affected by the disease, because of outward remodeling, plaques were mainly located at low shear stress regions. However, at later stages of the disease if lumen narrowing occurred, the plaque is also exposed to high shear stress. Until now it is not fully clear, what the influence is of high shear stress on these advanced lumen intruding plaques. Evidence is accumulating for a role of high shear stress in changes in plaque composition towards plaque destabilization and eventually plaque rupture. Moreover, not much studies investigated the influence of multidirectional shear stress on plaque progression and destabilization. In this lecture I will present the research that my group performed to investigate the role of (multidirectional) shear stress on plaque progression, destabilization and rupture at different stages of the atherosclerotic disease.

Keywords: Atherosclerosis.

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Jolanda Wentzel is Associated Professor Biomedical Engineering at the Cardiology Department, ErasmusMC, Rotterdam, the Netherlands and leads the Biomechanics Laboratory since 2005. The main purpose of her research group is to investigate the influence of biomechanical stress in the vascular system on the initiation, progression, destabilization and rupture of atherosclerotic plaques using image based modeling. For that purpose, she developed new 3D reconstruction techniques of coronary and carotid arteries applying fusion of multimodality imaging and histology. In those 3D reconstructions, she applies biomechanical modeling to assess shear stress and wall stress in arteries from patients, laboratory animals and individuals from population studies. For her work she received many national and international grants. She is recipient of an ERC-starters grant that allows her to study the combined effect of hemodynamic and structural stress on plaque destabilization and rupture. She published more than 120 papers in peer-reviewed scientific journals and is the co-founder of the annual International Symposium on Biomechanics in Vascular Biology and Cardiovascular Disease.