Prediction of atherosclerosis risk from a numerical and experimental investigation of blood flow in vessel branches

A. Otero-Cacho[1], M. Aymerich[1], M. T. Flores-Arias[1], M. Abal[2,3], E. Álvarez[2,3], P. Taboada[1], A. P. Muñuzuri[1], and V. P. Muñuzuri[1]
[1]Faculty of Physics, Universidade de Santiago de Compostela, Santiago de Compostela 15782, Spain
[2]Health Research Institute of Santiago de Compostela (IDIS), Fundación IDIS – SERGAS, Santiago de Compostela 15706, Spain
[3]Centro de Investigación Biomédica en Red – Enfermedades Cardiovasculares (CIBERCV), 28029 Madrid, Spain

Cardiovascular disease is the leading cause of dead. A very large portion of it is attributed to atherosclerosis-related problems. Understanding hemodynamics in blood circulation is, thus, crucial in order to unveil the mechanisms underlying the formation of atherosclerotic plaques.

We performed an exhaustive investigation in a simplified model aiming to characterize those regions in vessel bifurcations that are more likely to develop such lesions. Our investigation is based on numerical simulations (via CFD) and on in-vitro experiments realized in an ad-hoc designed polydimethylsiloxane (PDMS) channel [1]. The results obtained demonstrate that low velocity regions and low shear stress zones are located in the outer walls of bifurcations. In fact, we found that there is a critical range of bifurcation angles that is more likely to vascular disease than the others in correspondence with some previous experimental evidence. The effect of the inflow velocity on this critical range is also analyzed [2].

Furthermore, we carried out numerical simulations aiming to understand nano-and-microparticles behavior in blood flows through a blood vessel stenosis. Different shapes and sizes were analyzed [3].

[1] M. Aymerich, E. Álvarez, C. Bao-Varela, I. Moscoso, J. R. González-Juanatey, and M. T. Flores-Arias, Laser technique for the fabrication of blood vessels-like models for preclinical studies of pathologies under flow conditions, Biofabrication **9**, 025033 (2017).

[2] A. Otero-Cacho, M. Aymerich, M. T. Flores-Arias, M. Abal, E. Álvarez, V. Pérez-Muñzuri, and A. P. Muñuzuri, Determination of hemodynamic risk for vascular disease in planar artery bifurcations, Sci. Rep. **8**, 2795 (2018).

[3] A. Otero-Cacho, M. Aymerich, M. T. Flores-Arias, M. Abal, E. Álvarez, P. Taboada, A. P. Muñuzuri, and V. P. Muñuzuri, (in preparation)