33rd Scottish Fluid Mechanics Meeting
Multi-scale model of the fluid-structure interaction during flow mediated dilation for assessing vasodilation

George Hyde-Linaker, Richard Black, Asimina Kazakidi
Department of Biomedical Engineering, University of Strathclyde
University of Strathclyde,16 Richmond st, Glasgow, G1 1XQ

28th May 2020

Abstract

Cardiovascular diseases (CVDs) account for 33% of annual deaths, this approximates to 18 million people [1]. Vascular diseases arise in large part due to atherosclerosis, the hardening and narrowing of arteries due to plaque deposition. Atherosclerosis is associated with the impaired function of the endothelium. Therefore, quantifying a subject's endothelial dysfunction indicates the subject's CVD risk factor. Flow mediated dilation (FMD) is a popular and non-invasive clinical assessment of endothelial dysfunction. Measured ultrasonically, the arterial diameter of the brachial artery is assessed prior-to, during, and post-occlusion. The peak percent dilation of the brachial artery post-occlusion corresponds to the subject's endothelial function, this helps deduce a patient's CVD risk factor. Fluid-structure interaction (FSI) is a crucial aspect of FMD.

Computational fluid dynamics (CFD) offers a wide investigation into haemodynamic parameters that are not easily measurable in-vivo, such as pulse wave velocity (PWV) and wall shear stress (WSS). The model produced is a multi-scale CFD model incorporating an FSI element. The geometry being simulated is the bifurcation from the brachial artery to the radial and ulnar arteries. The model is subdivided into three parts; a 3D fluid domain, a 3D solid domain, and lumped parameter models. The fluid domain and solid domain are modelled in STAR-CCM+, whereas the lumped parameter models utilise Simcenter Amesim. The three sub-models are coupled to permit information exchange between them at each timestep, information between the fluid and solid domains are exchanged at the specified patch interfaces. The lumped-parameter models used are 3-element Windkessel models, these models are linked to an external stimulus that accounts for the FMD procedure. The FMD percentage calculated for the current idealized geometry being used was 7.9%, this is comparable to previous reports [2].

References

[1] S Mendis et al. World Health Organization in collaboration with the World Heart Federation and the World Stroke Organization. pp. 3–18, 2011.
[2] B Jang et al. Hypertension 57:1145–1150, 2011.