COMPUTATIONAL TOOLS FOR CLINICAL SUPPORT: A MULTI-SCALE COMPLIANT MODEL FOR HAEMODYNAMIC SIMULATIONS IN AN AORTIC DISSECTION

M. Bonfanti, S. Balabani, S. Homer-Vanniasinkam, V. Díaz-Zuccarini

Department of Mechanical Engineering, University College London, Torrington Place, London WC1E 7JE, United Kingdom

Computational fluid dynamics (CFD) has provided significant insight into the haemodynamics of many cardiovascular pathologies, and it is particularly amenable to study aortic dissection (AD) due to its complexity and patient-specific nature. AD is a vascular condition in which a tear in the intima layer allows the blood to flow within the aortic wall inducing the formation of two flow channels, the true (TL) and false lumen (FL), separated by an intimal flap (IF). Currently the treatment of choice for *uncomplicated* type B AD – those involving only the descending aorta – is medical therapy. However, whether this is the most ideal strategy is a topic of debate. In fact, up to 25-50% of the cases will develop complications requiring invasive treatment within 5 years. A preventive endovascular treatment could potentially improve the prognosis of the disease and avoid the difficulties and sub-optimal results of chronic procedures. CFD, by providing detailed information of complex intra-aortic haemodynamic parameters (e.g. pressure and blood flow in the FL), which currently cannot be determined *in vivo,* has the potential to aid clinical decision-making around AD; for instance, by identifying those prone to adverse outcomes and supporting clinicians by simulating different interventional strategies; however, oversimplified modelling assumptions and high computational cost compromise the accuracy of the information and impede clinical translation.

This poster presents a new workflow to set up patient-specific CFD models of ADs informed with non-invasive imaging data obtainable in the clinic (i.e. computed tomography (CT) scans, magnetic resonance imaging). The proposed multiscale computational approach includes a three-dimensional (3D) model of the dissected aorta, extracted from the patient's CT scans, coupled to a lower-order representation of the peripheral circulation (i.e. zero-dimensional Windkessel models). A novel and computationally efficient moving boundary algorithm was also implemented to capture the aortic compliance, which has been proved to significantly impact the blood flow and pressure field in dissected aortas. The parameters of the model were tuned using a flexible and robust procedure to represent the specific patient under investigation based on the available clinical data.

Comparisons between *in silico* and *in vivo* data showed that the proposed approach successfully captures flow and pressure waves for the patient-specific AD and is able to predict the pressure in FL, a critical variable for the clinical management of the condition. Results showed regions of low and oscillatory wall shear stress which, together with higher diastolic pressures predicted in the FL, may indicate risk of expansion. Being validated for a baseline condition, the model can be used to explore different interventional strategies (e.g. covering of the entry-tear with a stent-graft, fenestration of the IF) or medical treatments (e.g. β-blocker therapy) and analyse their effects on the fluid-dynamics in the dissection.

This study, at the interface of engineering and medicine, demonstrates a relatively simple and computationally efficient approach to account for arterial deformation and wave propagation phenomena in a three-dimensional model of AD, representing a step forward in the use of CFD as a potential tool for AD management and clinical support.