

A computational fluid dynamic investigation of the obesity-altered hemodynamics in children and adolescents

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Childhood obesity has become one of the major challenges of our century, taking epidemic proportions. Obesity, mainly a dietary disease, is known to advance endothelial dysfunction [1], an early sign of atherosclerotic lesions underling most cardiovascular diseases. Endothelial damage in high-risk paediatric patients can be clinically assessed with measurements of the aortic and carotid intima-media thickness (IMT), and flow-mediated dilatation (FMD) of the brachial, radial, and femoral arteries [2]. However, it is not yet clear how the haemodynamic environment is altered in this particular group of patients and which flow-related mechanisms contribute to early vascular changes. This work will discuss a computational model of an arterial conduit with compliant walls during FDM that attempts to clarify some of these aspects. Solutions to the time-dependent, incompressible Navier-Stokes equations are based on high-fidelity finite volume and hybrid Cartesian/immersed-boundary (HCIB) methods [3] that overcome several of the shortcomings of conventional computational fluid dynamic methods and provide increased spatial flow analysis. The codes have previously been validated and used extensively in various applications. Implementation of wall motion is particularly easy with HCIB methods, which are inherently capable of handling arbitrarily large body motions and allow for effective solutions of wall configuration. The model provides an evaluation of the haemodynamic shear stresses, a common indicator of early atherosclerotic lesion localisation. Future work will include multi-scale modelling that combines high-resolution 3D blood flow computations, with macroscopic and microscopic features of the vascular environment. Further haemodynamic metrics, such as the time-averaged wall shear stress (TAWSS), the oscillatory shear index (OSI), and the transverse WSS will also be assessed, in conjunction with patient data.

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References

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