SENSITIVITY OF INTRACRANIAL ANEURYSM HAEMODYNAMICS TOWARDS VARYING ARTERIAL TREE EXTENSIONS

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Introduction

Blood flow simulations of the human arterial system present a promising tool to help answer open questions about the advancement of vascular diseases and their possible causes. Vessel malformations in the brain region, such as Intracranial Aneurysms (IA), pose a special challenge due to their delicate location and an overall heterogeneous arterial morphology between patients [1]. One key component required to obtain physiologically accurate flow profiles is adequately simulating the peripheral flow surrounding the region of interest. To further develop this topic, this study assesses the influence of different 3D domain extensions on IA haemodynamics.

Methods

Three patient geometries centered at the Circle of Willis are investigated, each harbouring an IA at the PCom-ICA junction (see Figure 1). The segmented geometries are varied progressively by reducing their spatial extension, resulting in three extension levels. The incompressible Navier-Stokes equations are solved numerically with generalized pulsative inflow conditions [2]. The intrinsically shear-thinning rheology of blood is described through the Carreau-Yasuda model. Outlet boundary conditions are derived from the Principle of Minimum Work and transformed into pressure conditions. The results are compared by inspecting the flow characteristics and common risk indicators, such as the Wall Shear Stress (WSS) and the oscillatory shear index [1].

Results

The obtained haemodynamic profiles show that locally constrained arterial trees can in some cases lead to considerable differences in flow structures, even in qualitative terms. The alterations of the flow are consistent with the changes of fluxes at the aneurysm's bifurcation and are therefore case-dependent. The WSS accordingly changes in magnitude and location following the change of the primary variables. Oscillatory shearing, caused predominantly by chaotic flow patterns, is found in regions of low shearing inside the dome.

Discussion

Different domain extensions can cause substantial changes in local haemodynamics. Their qualitative and quantitative measures however remain patient-dependent. IAs located at either of the posterior communicating arteries must be treated carefully since no general boundary condition model for this vessel type has been identified as optimal by the research community. The work affirms that simulation parameters, such as the domain size, can cause considerable inter-patient variability [3, 4] and should be treated following an elaborated unified strategy.

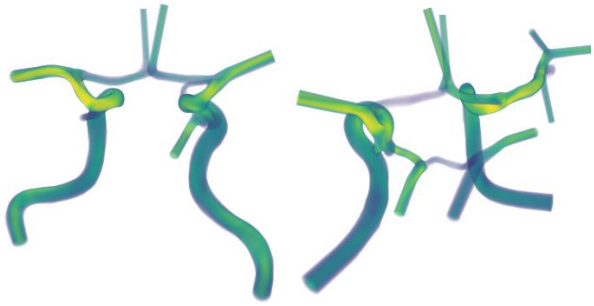

Figure 1: Maximum intensity projections of the flow velocity at diastole of two patients with ICA-PCom bifurcation aneurysms.

References

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