NUMERICAL SIMULATION OF CEREBRAL ANEURYSM BY FLOW DIVERSION

Asimina Kazakidi[1]**, Fotis Drakopoulos**[2]**, Chander Sadasivan**[3]**,**
Nikos Chrisochoides[2]**, John Ekaterinaris**[4]**, Baruch B. Lieber**[3]

[1]Institute of Computer Science, Foundation for Research & Technology - Hellas, Greece
e-mail: kazakidi@ics.forth.gr
[2] Department of Computer Science, Old Dominion University, Norfolk, VA, USA
e-mail: {fdrakopo, npchris}@gmail.com
[3] Department of Neurological Surgery, Stony Brook University, Stony Brook, NY, USA
e-mail: {Chandramouli.Sadasivan, Baruch.Lieber}@stonybrookmedicine.edu
[4] Embry-Riddle Aeronautical University Daytona Beach, 32114 FL, USA
e-mail: ekaterij@erau.edu

Intracranial aneurysms are abnormal focal enlargements of the vascular walls that require immediate surgical intervention once detected. Emerging stent technology involves an innovative type of finely-braided stents, called flow diverters, which abruptly impede the arterial flow into the aneurysm, upon deployment, and induce thrombosis, vascular remodelling and complete aneurysm occlusion in under a year [1]. The understanding of the dynamics of blood flow within this radically modified environment is thought to be pivotal in increasing the efficacy of both stent design and prolonged treatment. The aim of the current study is to numerically simulate the blood flow within stented arterial segments and to evaluate critical hemodynamic factors around the aneurysm neck, validated with clinical and experimental data [1, 2]. These objectives are particularly challenging for geometries reconstructed from medical images, due to poor image resolution and inadequate mesh refinement of the 3D vasculature. Following a novel Body-Centric Cubic (BCC) mesh generation method [2], high-fidelity tetrahedral meshes of aneurysmal dilatations that incorporate flow diverters across the aneurysm neck are now possible with an accurate image-to-mesh (I2M) conversion scheme from micro-CT images (Fig. 1). Preliminary results involve arterial segments both with and without flow diverters (e.g. Fig. 2), utilising the open-source CFD software OpenFOAM® to solve the incompressible Navier-Stokes equations, under steady and physiologically-correct pulsatile flow conditions.
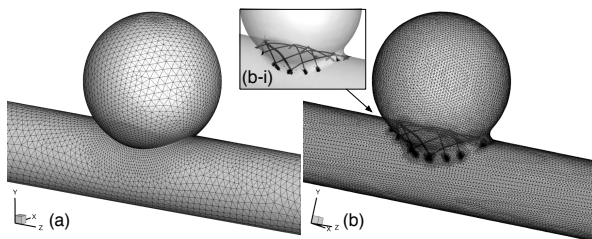

Figure 1: Idealized sidewall aneurysms of (a) a CAD-based geometry without stent and (b) a micro-CT reconstruction of silicone replica with embedded flow diverter (inset). (a) Simple mesh. (b) High-quality BCC-based mesh.
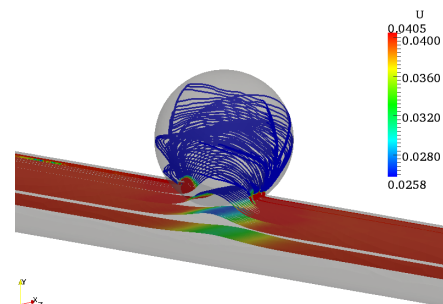

Figure 2: Volume streamlines colored according to the velocity magnitude (U) of an idealized aneurysmal geometry with no flow diverter, at $Re = 42$.

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