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FLOW DIVERTER STENT PERFORMANCE AT DIFFERENT FLOW RATE CONDITIONS

Hernán G. Morales[1] and Odile Bonnefous[1]

[1] Medisys - Philips, France. {hernan.morales, odile.bonnefous}@philips.com

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Intracranial aneurysms are irreversible dilatations of the cerebral arteries often occurring at branching points of the circle of Willis. To treat them, flow diverter (FD) stents have arisen as a promising alternative to traditional clipping and endovascular coiling. FD redirects the flow away from the aneurysm cavity, thus reducing the flow speed and increasing its resident time inside the aneurysm. Through computational fluid dynamics (CFD), it is possible to assess the local hemodynamic alterations after FD placement, and to evaluate its performance before the real treatment take place. Nevertheless, FD performance at different flow rates has not been studied.

One image-based aneurysm model was used in this study. A 3D medical image of the vasculature was acquired by an Allura Xper FD20 system of Philips Healthcare. After segmentation of the medcial image, surface mesh edition and volumetric mesh generation were done. CFD simulations were performed using OpenFoam v2.2.1 [1]. Arterial and aneurysm walls were considered as rigid with no slip boundary condition. Blood was assumed to be an incompressible Newtonian fluid with density ρ=1060 kg/m^3 and viscosity μ=0.0035 Pa·s. Zero-pressure conditions were imposed at the outlets. A parabolic profile was set at the inlet. A physiological flow waveform was extracted from a DSA sequence acquired during a clinical procedure, using a dedicated optical flow technique [2, 3]. This waveform was scaled to produce 5 physiological flow rate curves, from 1.0 mL/s to 5.0 mL/s, at step of 1.0 mL/s. Additionally, an injected contrast propagation was simulated by including a scalar transport equation in the CFD setup following a previous study [4].

To model the effect of the FD model on intra-aneurysmal hemodynamics, a porous medium was used [5]. Basically, the governing equations of fluid flow were reformulated on those cells intersected by the FD. The reformulated equations include a porosity term and a pressure loss term. The FD was virtually placed at the middle cerebral artery using the parent vessel reconstruction tool from the *Vascular Modeling Toolkit* [6]. FD porosity was set equal to 72%, mimicking a Silk FD stent. To assess the FD performance, the contrast concentration inside the aneurysm before and after FD were calculated (Fig. 1A).

Flow rate influences the FD performance. Treated models have lower contrast concentration inside the aneurysm than untreated ones, showing the influence of FD placement (Fig. 1A). Contrast modulation was severely diminished for FRs<2 mL/s and its concentration depends on the flow rate (Fig. 1B).

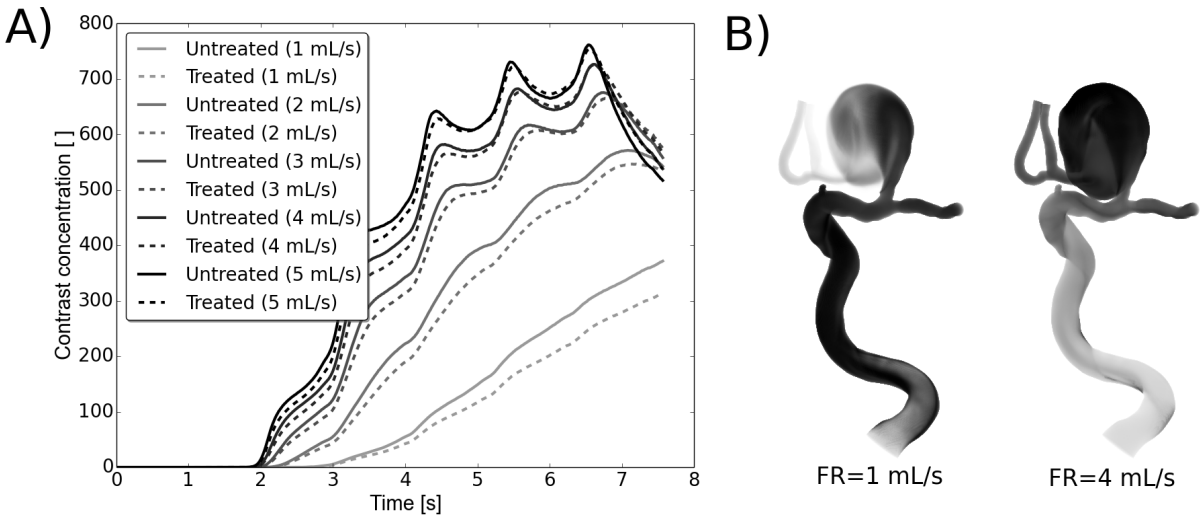

Figure 1: A) Contrast concentration for untreated and treated models at different flow rates. B) Volume rendering of the contrast propagation of two untreated models at time=6.5 s.

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