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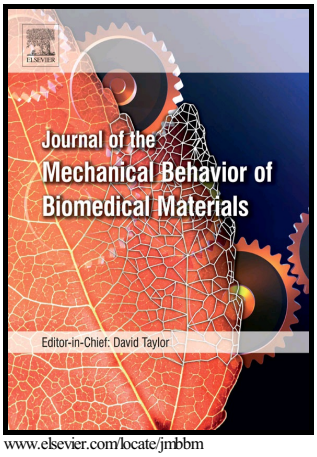

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Fluid–structure interaction simulation of a cerebral aneurysm: effects of endovascular coiling treatment and aneurysm wall thickening

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In the present study, we investigate the effect of the hemodynamic factors of the blood flow on the cerebral aneurysms. To this end, a hypothetical geometry of the aneurysm in the circle of Willis, located in the bifurcation point of the anterior cerebral artery (ACA) and anterior communicating artery (ACoA) is modeled in a three-dimensional manner. Three cases are chosen in the current study: an untreated thin wall (first case), untreated thick wall (second case), and a treated aneurysm (third case). The effect of increasing the aneurysm wall thickness on the deformation and stress distribution of the walls are studied. The obtained results showed that in the second case, a reduction in the deformations of the walls was observed. It was also shown that the Von Mises stress has a 10 percent reduction in the untreated thick wall aneurysm compared to the untreated thin wall aneurysm. Thus, increasing the thickness of the aneurysm wall can be proposed as temporary remedial action. In the third case, an aneurysm that has been treated by endovascular coiling is investigated. The deformation and Von Mises stress in this case was decreased more than 43 and 87 percent compared to the first case, respectively. The wall shear stress distribution due to the fluid flow in the first and second cases showed small amounts of shear stress on the aneurysm sac. In these two cases, the oscillatory shear index was measured to have an approximate value of 0.47 in the aneurysm region, though, this value was measured to be about 0.1 for the third case. The hybrid effect of the wall shear stress and the oscillatory shear index on the relative residence time (RRT) was also studied. When this parameter reaches its maximum, the aneurysm rupture may occur. It was shown that by treating the aneurysm (the third case), RRT parameter can be decreased ~ 200 times relative to the first and second cases, which suggests an appropriate treatment of the aneurysm by choosing the coiling method.

Keywords: cerebral aneurysm, aneurysm wall thickening, endovascular coiling treatment, vessel wall hyperelastic behavior, fluid-structure interaction, non-Newtonian properties of blood.