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PII: S0021-9290(13)00413-2
DOI: http://dx.doi.org/10.1016/j.jbiomech.2013.09.004
Reference: BM6280

To appear in: *Journal of Biomechanics*

Accepted date: 1 September 2013

Cite this article as: Øyvind Evju, Kristian Valen-Sendstad, Kent-Andre Mardal, A study of wall shear stress in 12 aneurysms with respect to different viscosity models and flow conditions, *Journal of Biomechanics,* http://dx.doi.org/10.1016/j.jbiomech.2013.09.004

A study of wall shear stress in 12 aneurysms with respect to different viscosity models and flow conditions☆

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Abstract

Recent computational fluid dynamics (CFD) studies relate abnormal blood flow to rupture of cerebral aneurysms. However, it is still debated how to model blood flow with sufficient accuracy. Common assumptions made include Newtonian behavior of blood, traction free outlet boundary conditions and inlet boundary conditions based on available literature. These assumptions are often required since the available patient specific data is usually restricted to the geometry of the aneurysm and the surrounding vasculature. However, the consequences of these assumptions have so far been inadequately addressed.

This study investigates the effects of 4 different viscosity models, 2 different inflow conditions and 2 different outflow conditions in 12 middle cerebral artery aneurysms. The differences are quantified in terms of 3 different wall shear stress (WSS) metrics, involving maximal WSS, average WSS, and proportion of aneurysm sac area with low WSS. The results were compared with common geometrical metrics such as volume, aspect ratio, size ratio and parent vessel diameter and classifications in terms of sex and aneurysm type.

The results demonstrate strong correlations between the different viscosity models and boundary conditions. The correlation between the different WSS metrics range from weak to medium. No strong correlations were found between the different WSS metrics and the geometrical metrics or classifications.

Keywords: Cerebral aneurysms, computational fluid dynamics, wall shear stress, non-Newtonian fluid, boundary conditions.

☆Word count: 2765 (Introduction through Conclusion)

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