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RESEARCH CENTER FOR COMPUTATIONAL NEUROVASCULAR BIOMECHANICS
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Effects of Non-Newtonian Viscosity on the Hemodynamics of Cerebral Aneurysms

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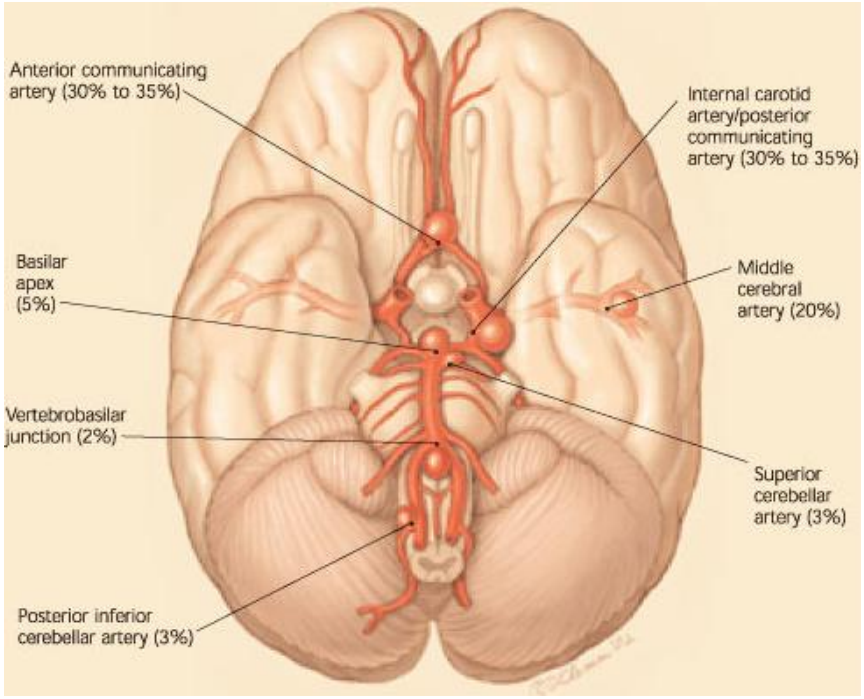
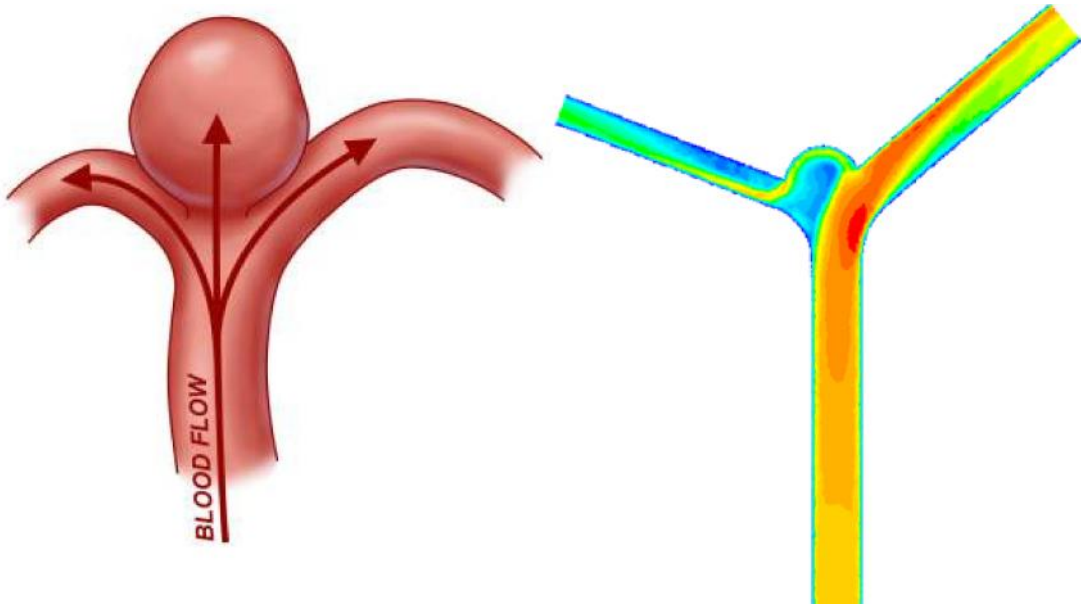
Joint research work between AASTMT and Research Center for Computational Neurovascular Biomechanics (RCCNB)

Problem Definition

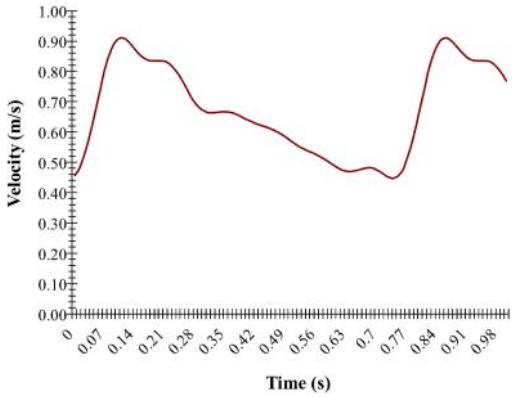
Aneurysm is a localized, balloon like bulge of the arterial wall. Ceberal aneurysm occurs in the circle of Willis, the arterial network which feeds the brain.

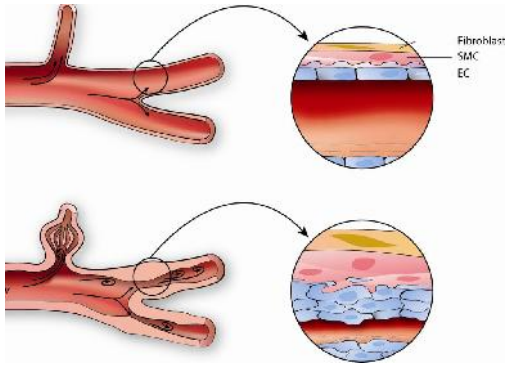




Problem Definition

- Blood flow in pulsating (unsteady) with different frequencies and time scales.
- The flow within the aneurysm is a pulsating free jet.
- Aneurysm wall responds mechanically, biologically and biochemically to the blood flow.
- Blood flow responds dynamically to the changes (i.e. remodelling) of the aneurysm and arterial walls.
- The phenomena is substantially **COMPLEX !**





Problem Definition
A CFD Approach

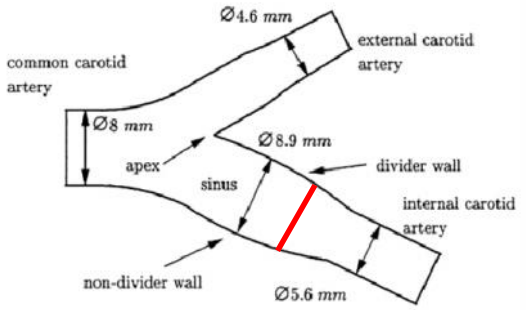
- Most CFD studies of aneurysm hemodynamics assumes:
  1. Laminar Flow
  2. Newtonian blood viscosity

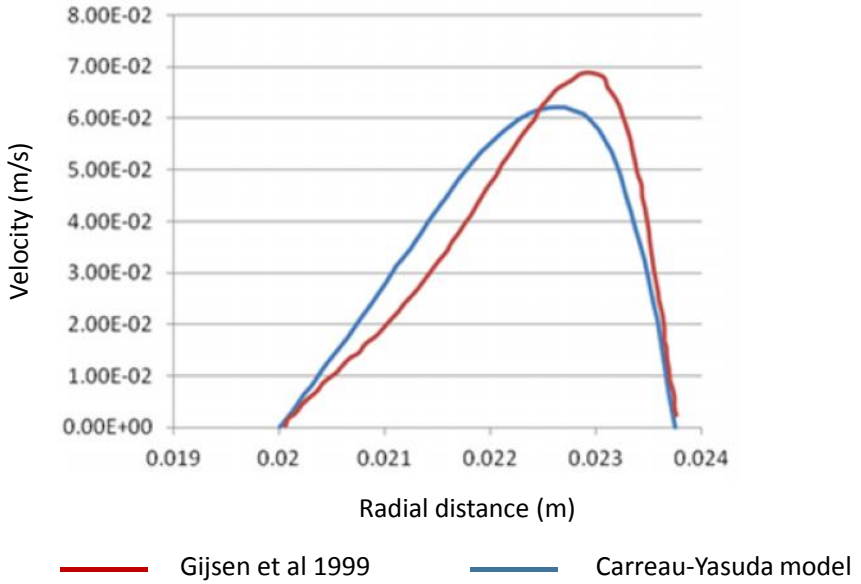
- **These assumptions do not match the results of *in-vivo* examination of aneurysm wall !**
  - Endothelial dysfunction occurs in disturbed (i.e. transitional/turbulent) flow → **Laminar flow assumption is invalid**
  - In order for transition to occur, the Newtonian blood viscosity model becomes illicit → **Reynolds number is or the order of 100**

- This studies investigates the effect of Non-Newtonian viscosity models on shear stress predictions of patient-specific cerebral aneurysm

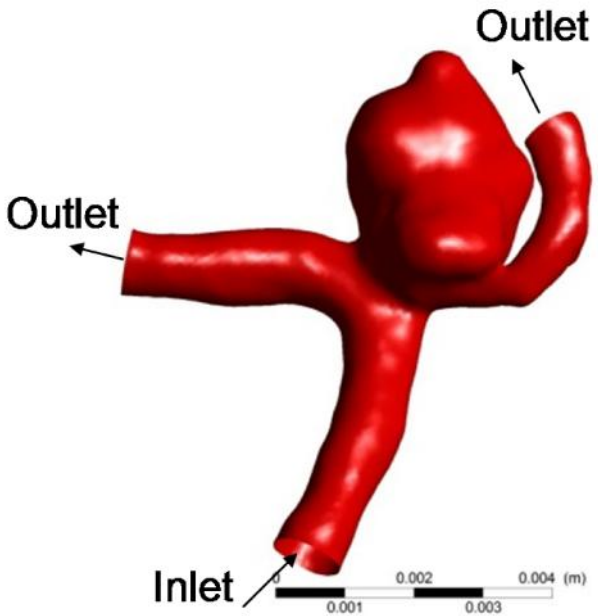
CFD Modelling: Validation

- An idealized carotid bifurcation case was used to validate the non-Newtonian blood flow model (Gijsen et al, 1999)

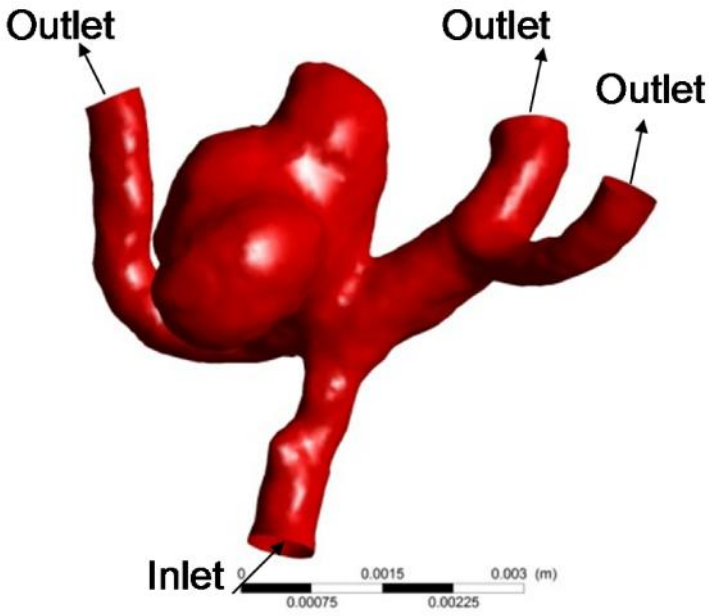




CFD Modelling: Patient-Specific Models



(a) MCA Aneurysm model



(b) AComA Anerusym model

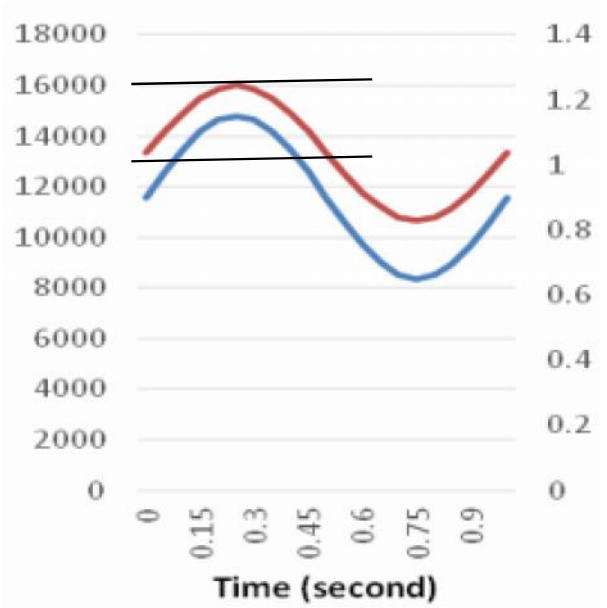
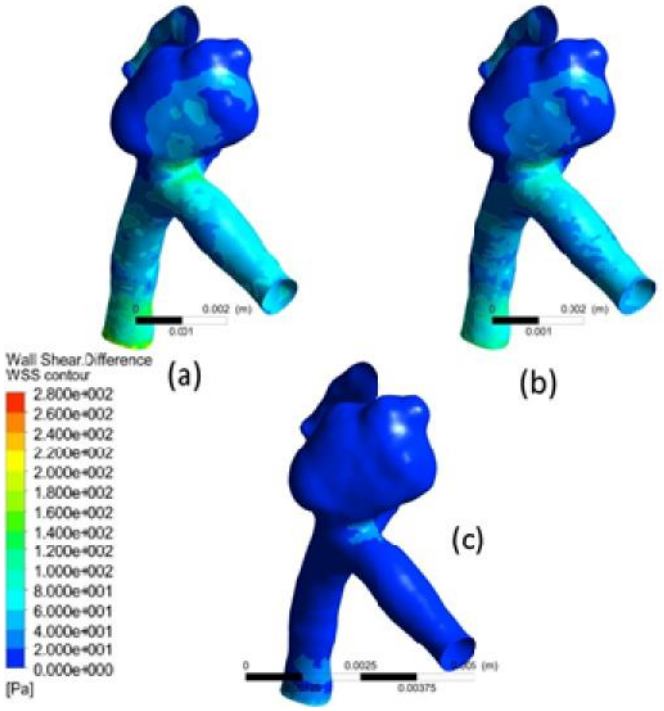
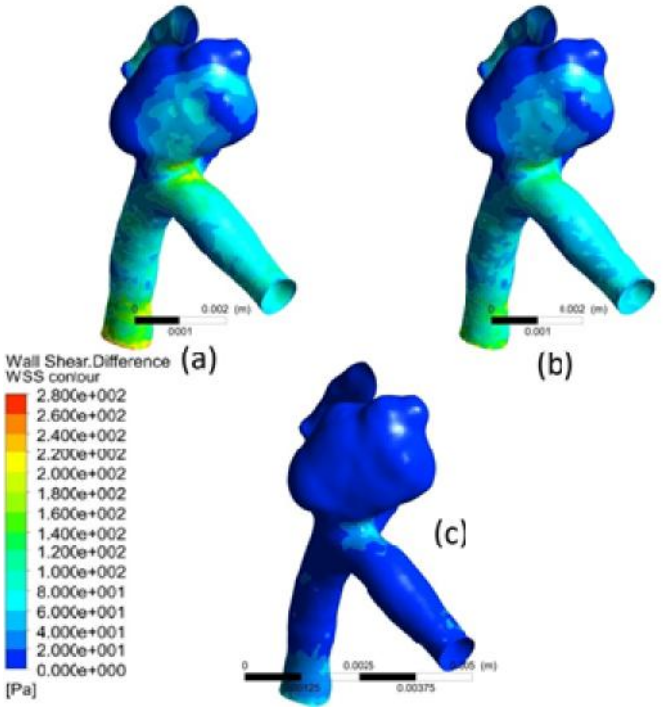


Figure 1. Patient specific aneurysm models derived from 3D angiography scanning

CFD Modelling: MCA Aneurysm

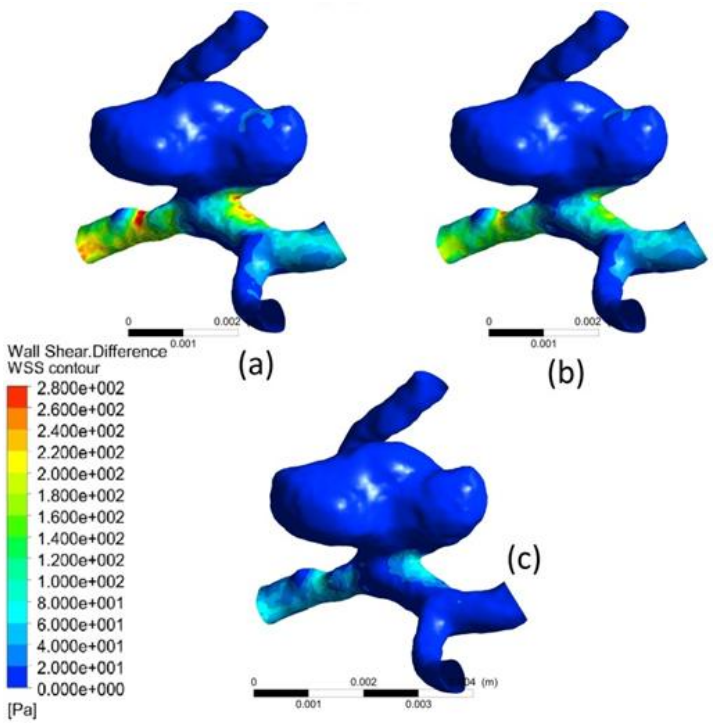


Flow at half of the cycle for case 1 (a) Newtonian Viscosity (b) Non-Newtonian Viscosity (c) Difference between viscosities effect on overall WSS values.

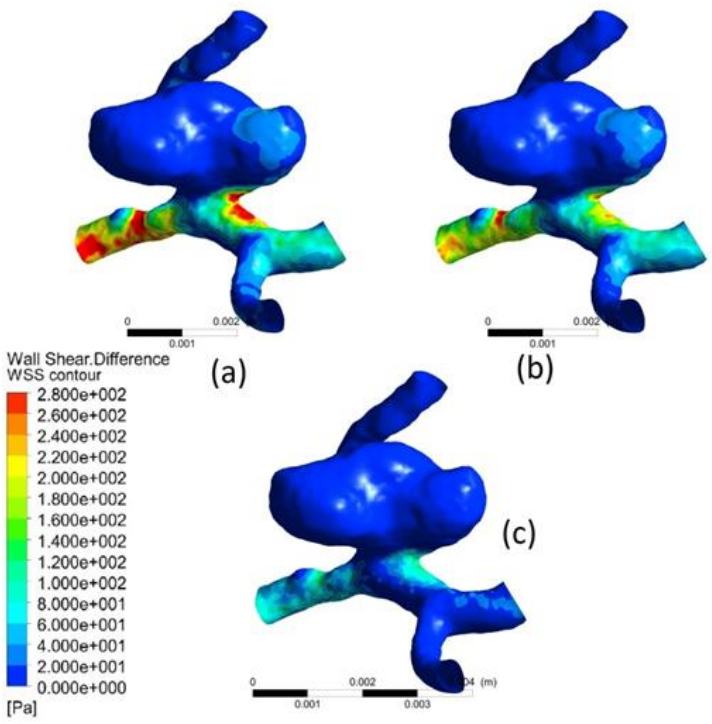


Flow at Peak of the cycle for case 1 (a) Newtonian Viscosity (b) Non-Newtonian Viscosity (c) Difference between viscosities effect on overall WSS values.

CFD Modelling: AComA Aneurysm



Flow at half of the cycle for case 2 (a) Newtonian Viscosity (b) Non-Newtonian Viscosity (c) Difference between viscosities effect on overall WSS values.



Flow at peak of the cycle for case 2 (a) Newtonian Viscosity (b) Non-Newtonian Viscosity (c) Difference between viscosities effect on overall WSS values.

Conclusion and Recommendation

- The non-Newtonian model predicts lower threshold of WSS values, and slightly severe gradients.
- Low WSS values on the aneurysm wall are known to be an important rupture risk factor, and severe gradients do contribute to the aneurysm growth via a pathological route.
- Hence, the present study recommends the use of non-Newtonian viscosity models in patient specific simulations of cerebral aneurysms.