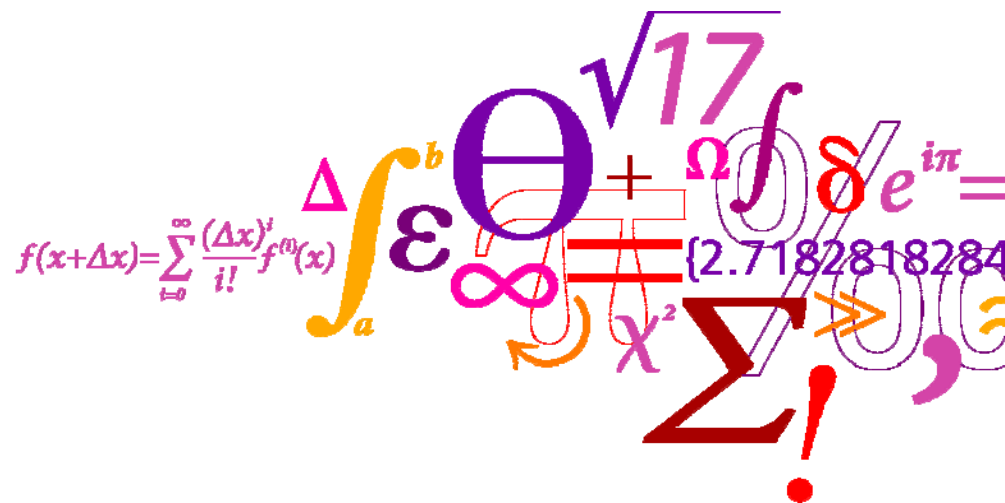




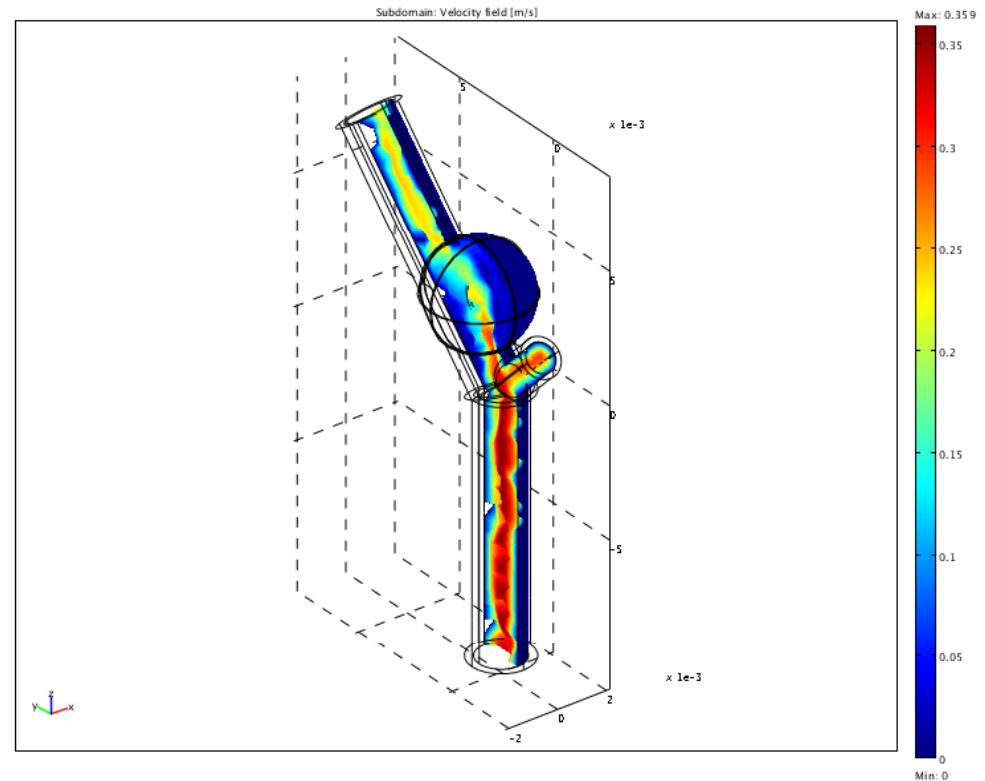
Using COMSOL Multiphysics for Biomechanical Analysis of Stent Technology in Cerebral Aneurysms

Presentation by Joachim Rasmussen



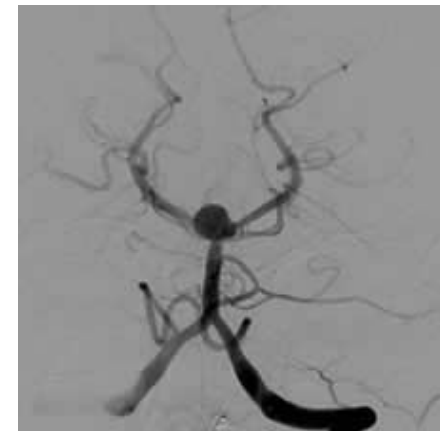
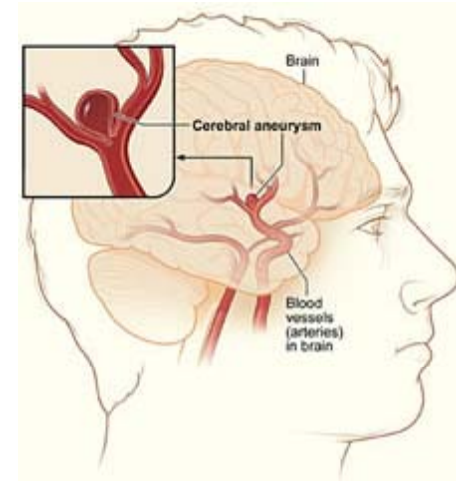
Welcome

- Introduction
- Simulation setup and results
- Conclusion



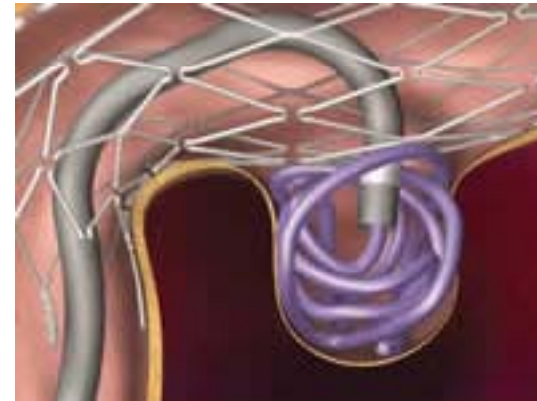
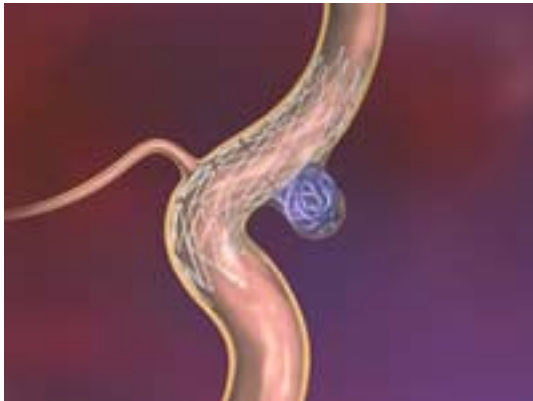
Aneurysms

- Focal dilation of the arterial wall
- Saccular aneurysm most common in cerebral vasculature - 90% *Berry Aneurysm*
- Up to 30mm in diameter
- Silent until rupture



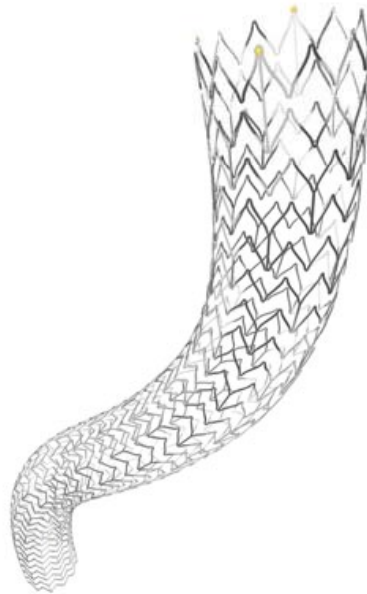
Source: MUSChealth

Treatment techniques – Stent assisted coiling



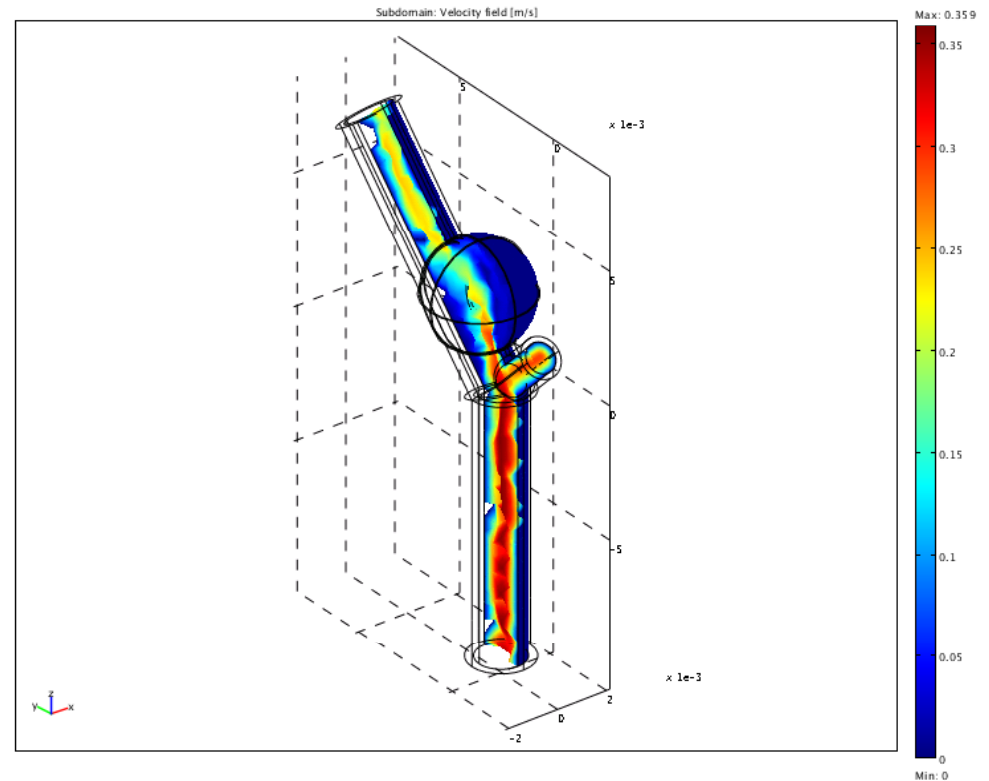
Source: MUSHealth

Treatment techniques – Stenting?

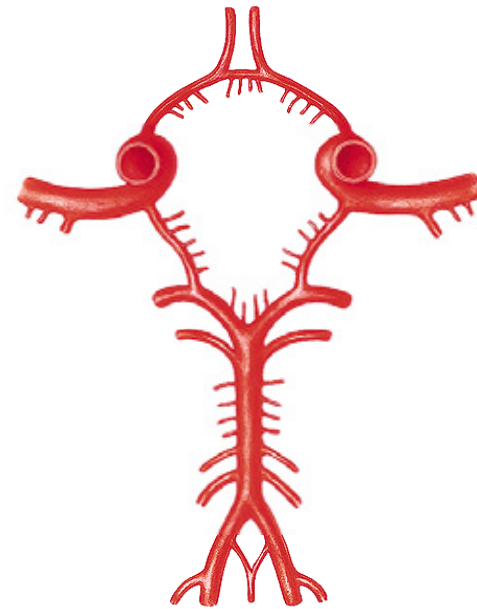
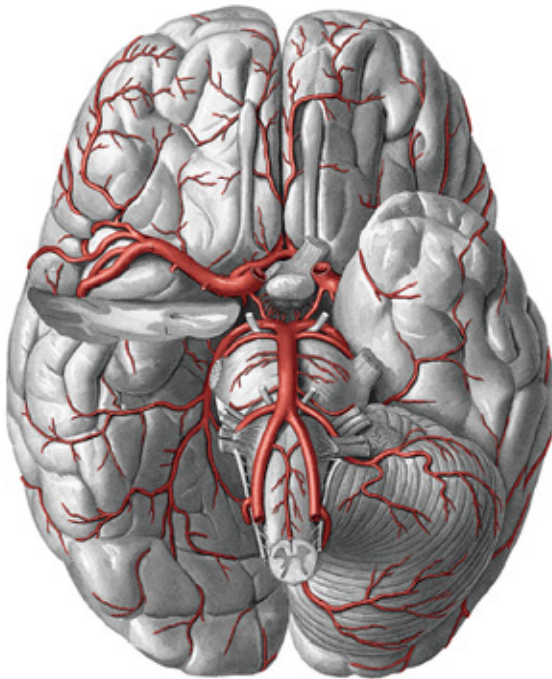


Source: COOK

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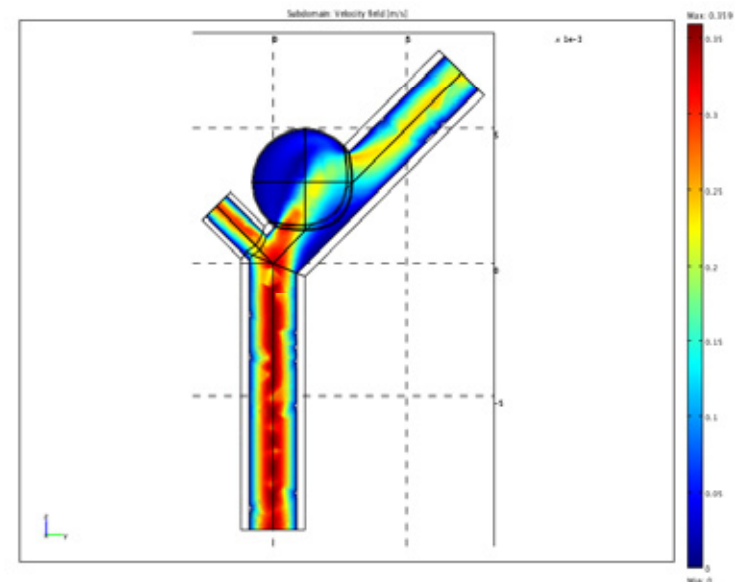
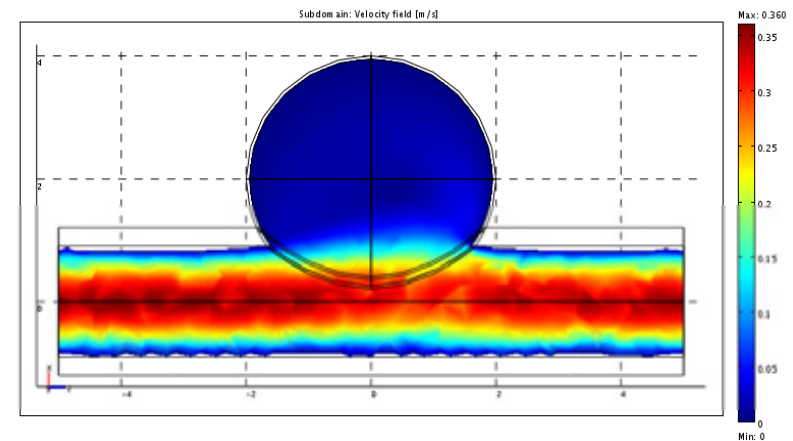
The cerebral vasculature



Source: Sobotta

ACA & ACoA model

- Section of Anterior Cerebral Artery with or without ACoA branch
- 3D FSI simulations
- Neo-Hookean hyperelastic vessel wall
- Mooney-Rivlin hyperelastic aneurysmal wall
- Newtonian fluid
- Laminar inlet flow
- Constant outlet pressure



Stent simulation

Porosity simulation



Source: COOK

Stent porosity simulation

Chemical Engineering Module – Porous Media Flow – Brinkman Equation

2 adjustable parameters:

Porosity, ε

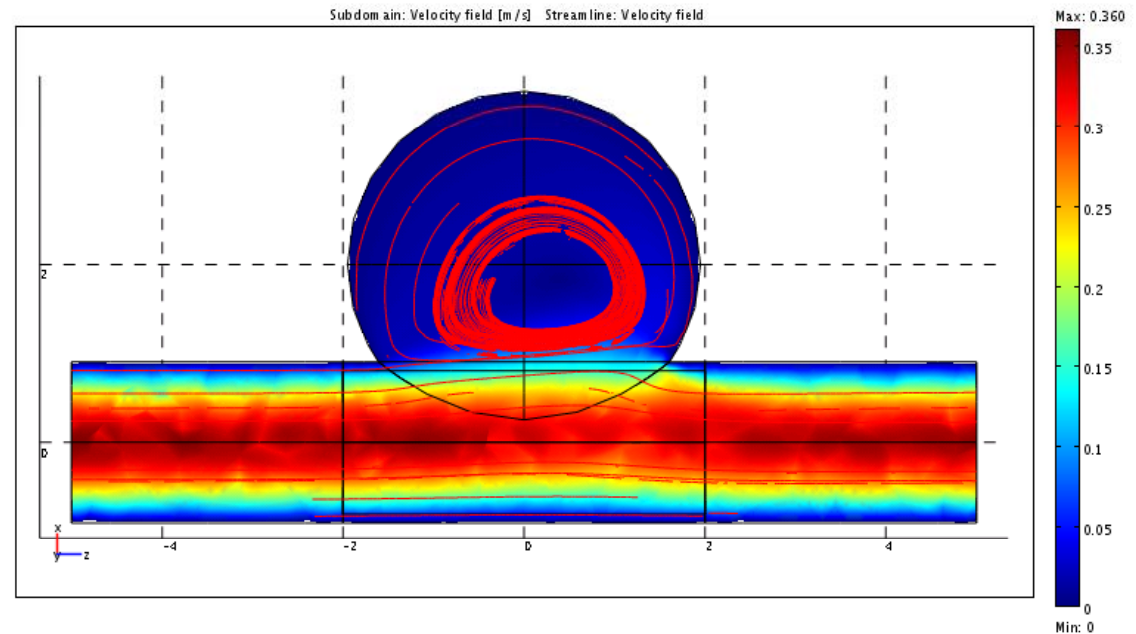
$$\varepsilon = \frac{V_{void}}{V_{total}}$$

Hydraulic permeability, K

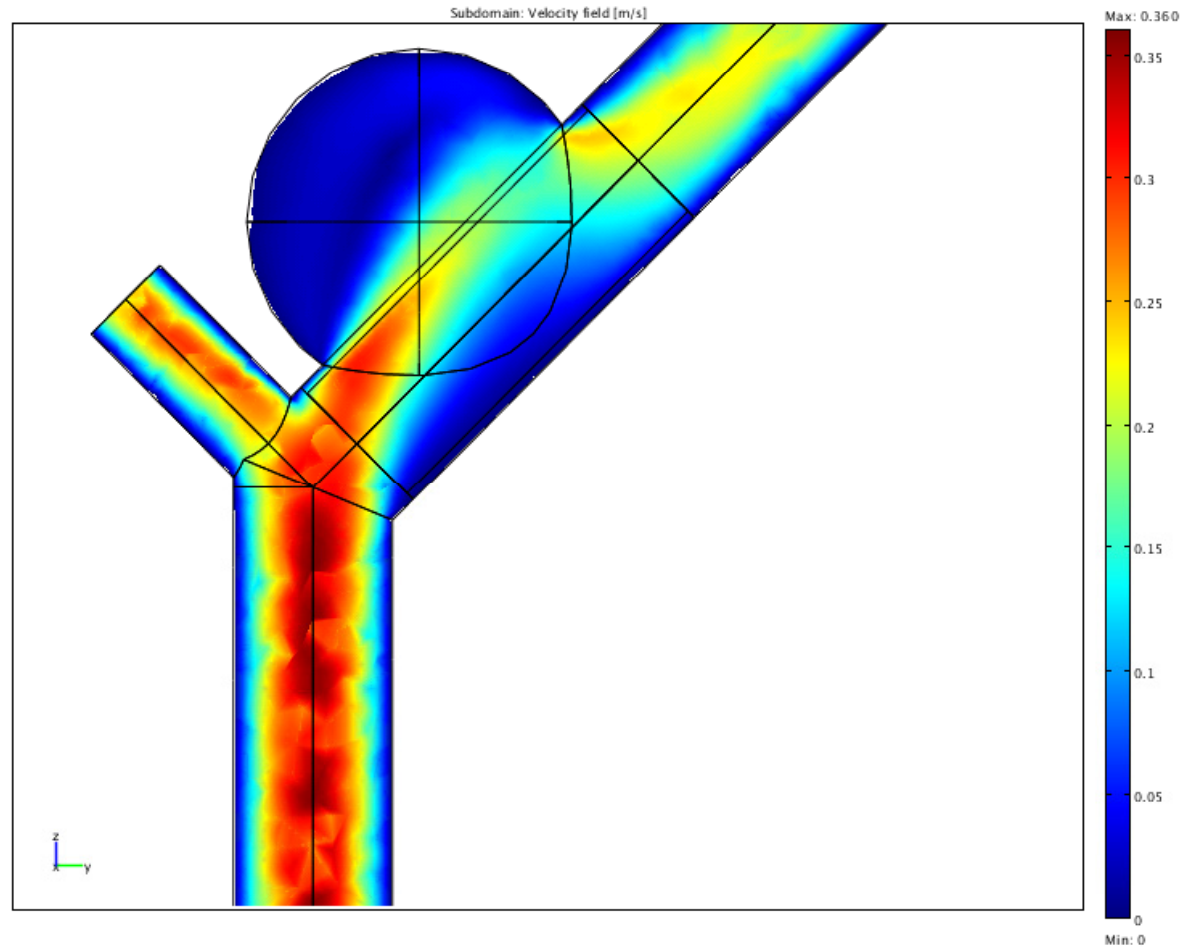
$$K = \frac{C \varepsilon^3}{\mu S^2}$$

ACA stent porosity simulation

- Section of Anterior Cerebral Artery
- 3D simulation
- Newtonian fluid
- Laminar inlet flow
- Constant outlet pressure

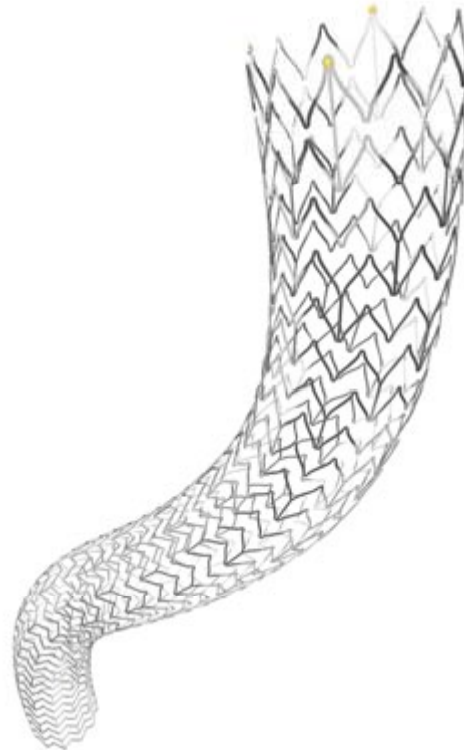


ACoA stent porosity simulation



Stent simulation

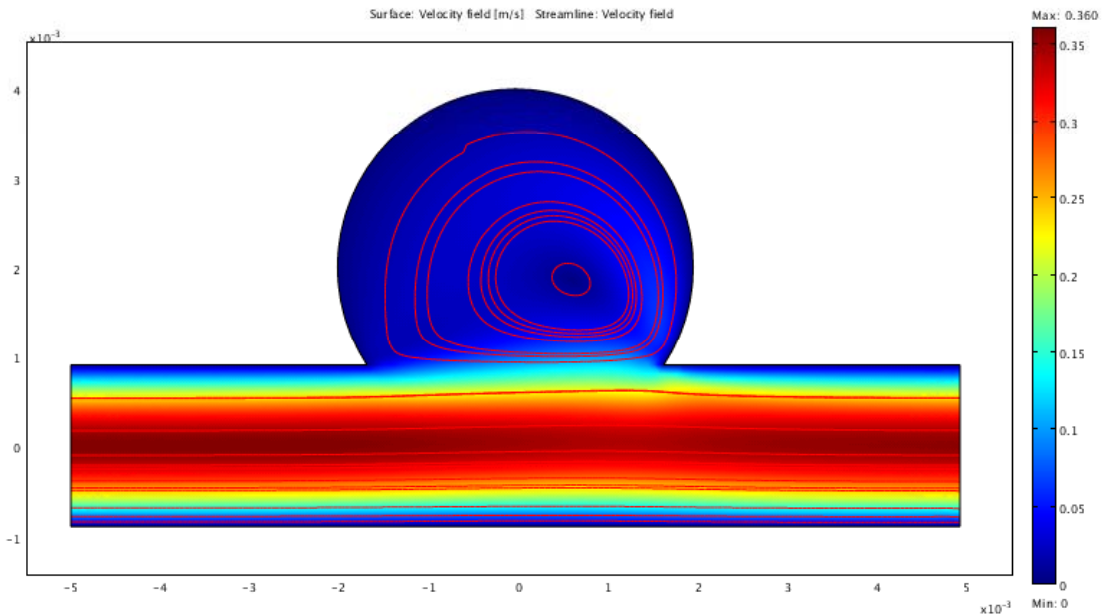
Strut setup simulation



Source: COOK

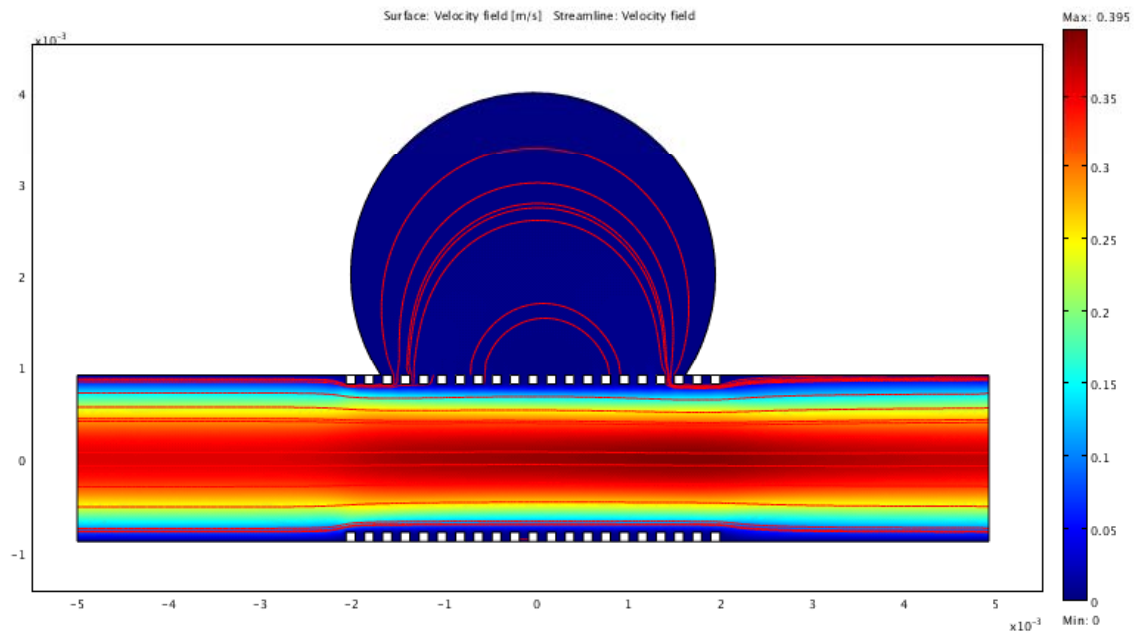
ACA stent strut simulation

- Section of Anterior Cerebral Artery
- 2D model
- Non-Newtonian fluid
- Laminar inlet flow
- Constant outlet pressure

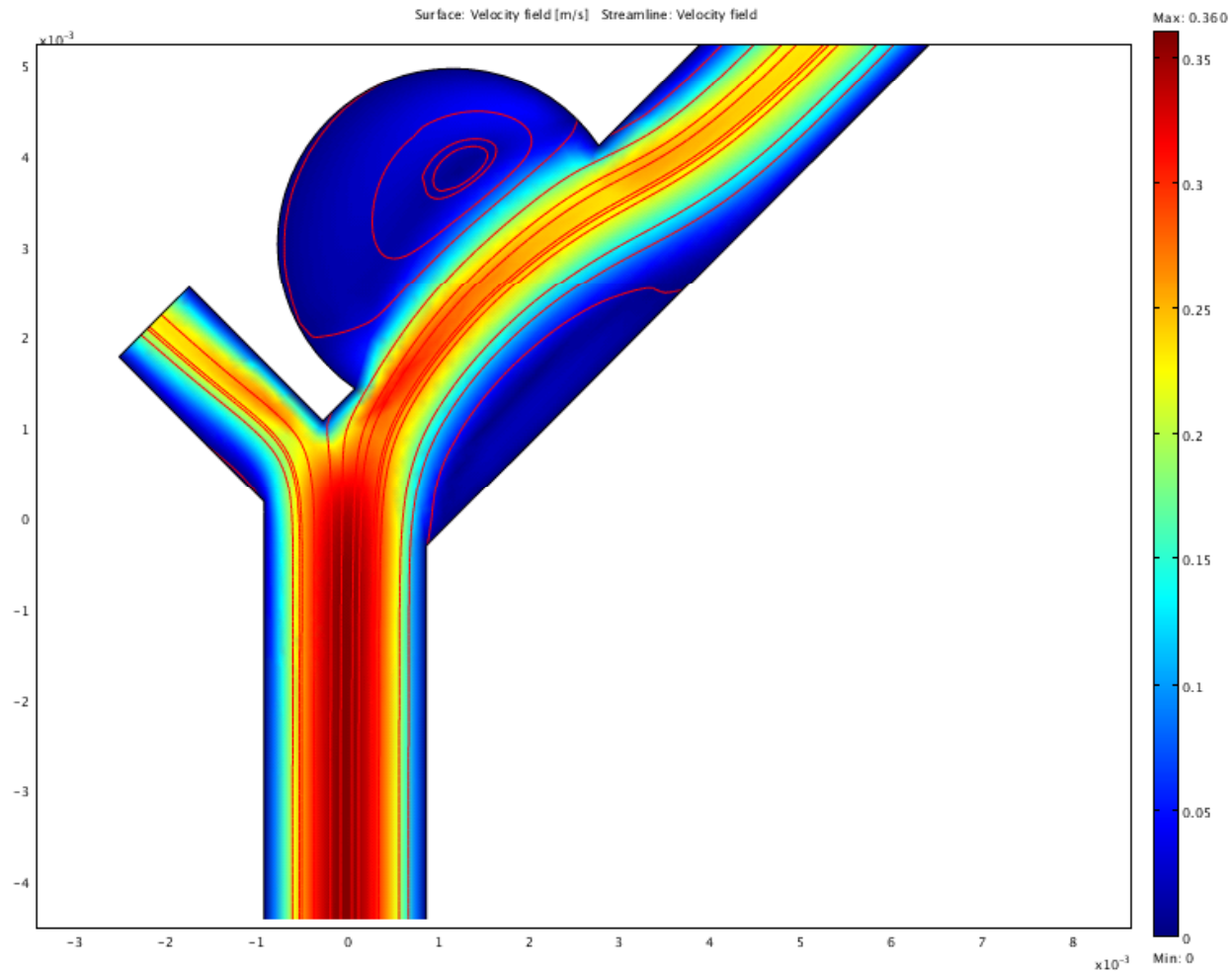


ACA stent strut simulation

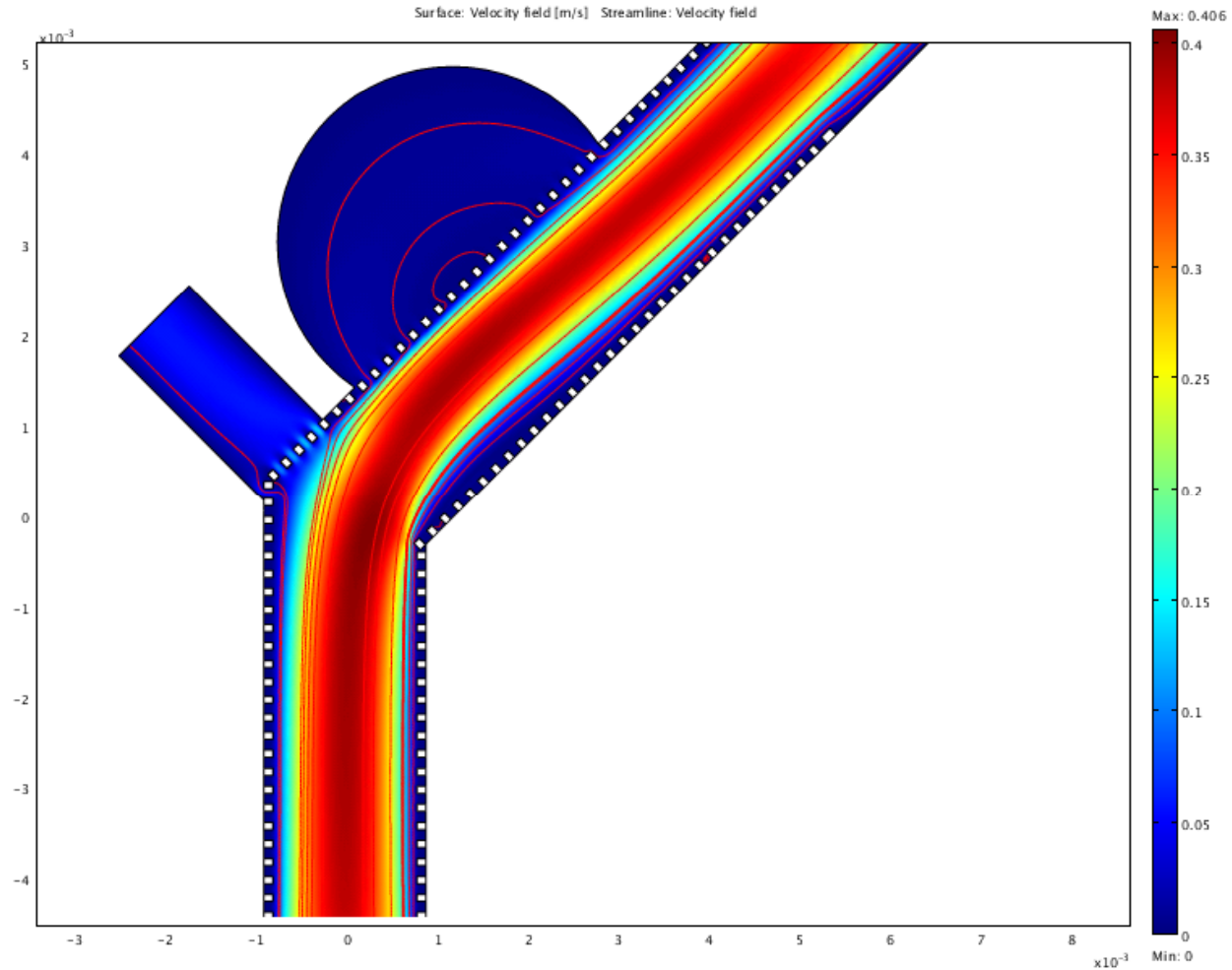
- Shape
- Strut size
- Mesh size



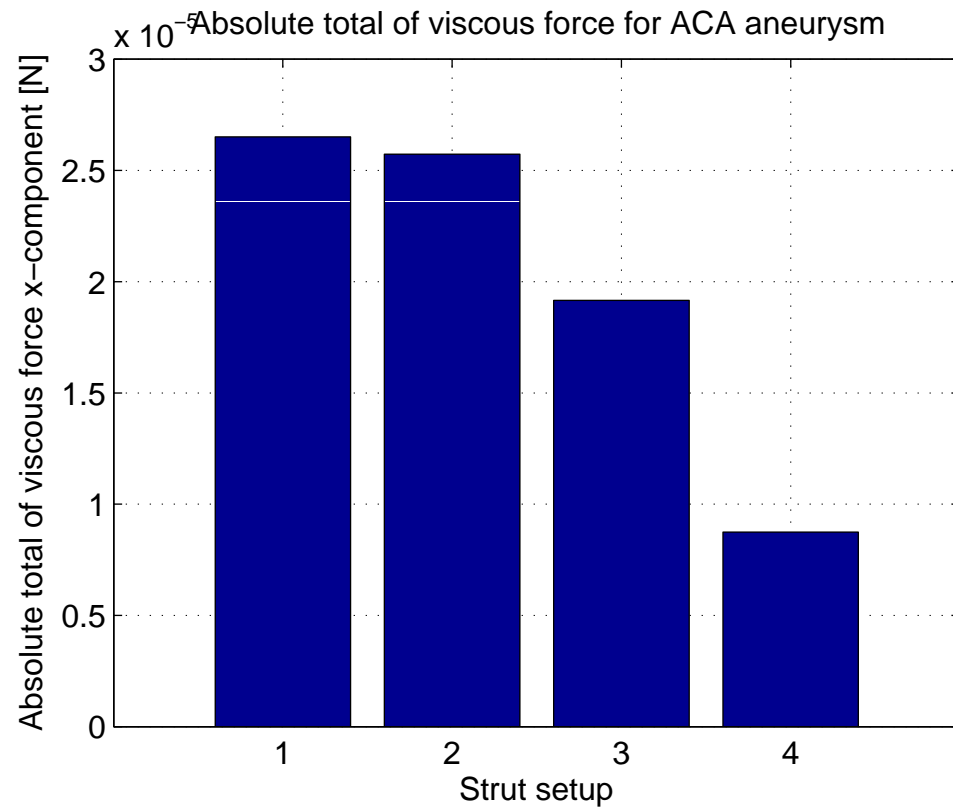
ACoA stent strut simulation



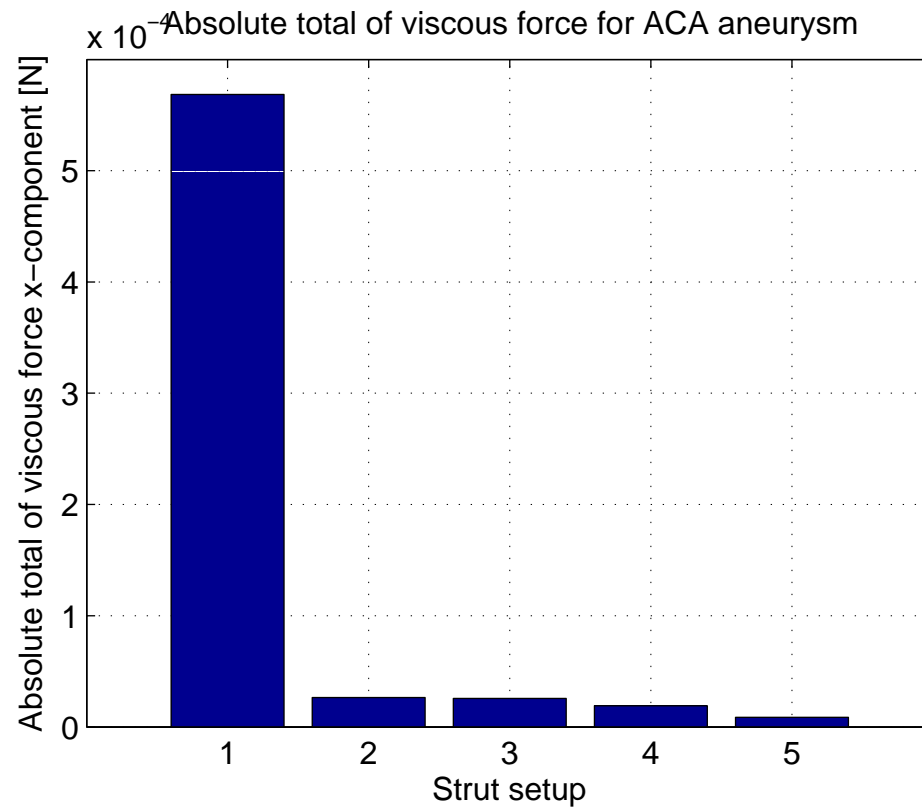
ACoA stent strut simulation



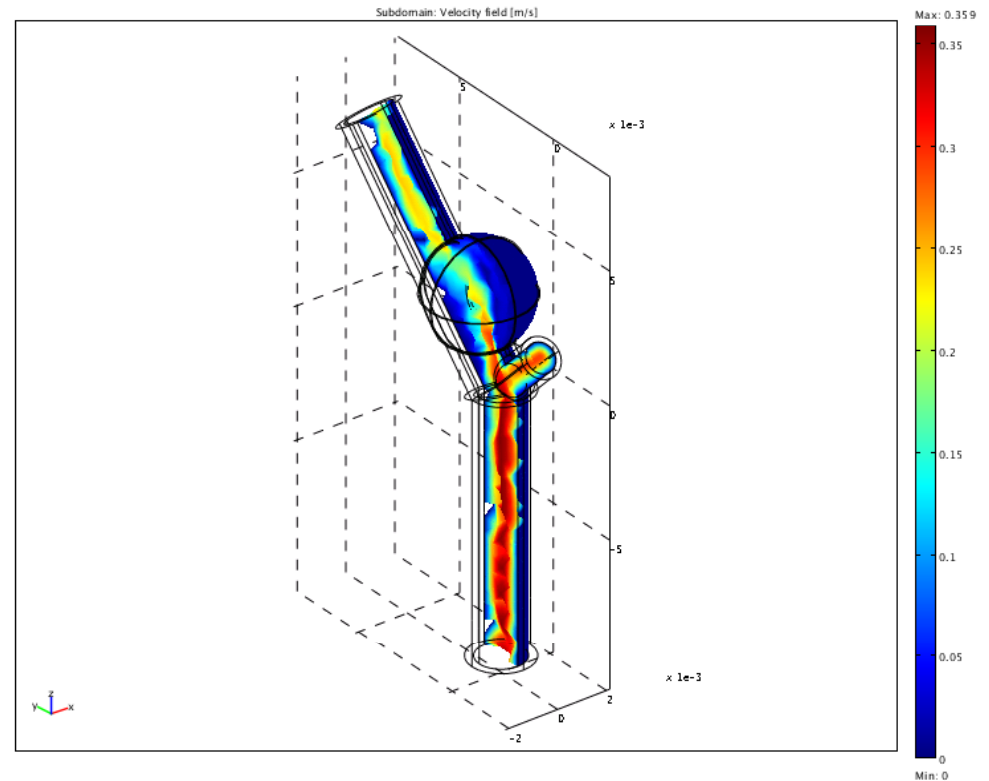
ACA stent strut simulation



ACA stent strut simulation



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Conclusion

- Possible to reduce aneurismal blood flow using stents
- Small pore/mesh design
- Stent efficiency highly dependent on strut design
- Drain sections for arterial branches

Conclusion - Future Work

- Fung-type non-linear materials
- 3D strut models
- CAD drawings
- Blood velocity measurements
- Thrombosis trigger
- Patient specific models

Thank you!

Sources

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- *Sobotta* - J. Sobotta. *Sobotta Anatomie des Menschen, Der komplette Atlas in einem Band*. Urban & Fischer, 22nd edition, 2007
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