Vessel Stress

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October 20, 2017
C3-ATI Mobil In-Vitro Neurovascular Cast System
ME 486C – Section 8
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Introduction:

Aneuvas Technologies Inc, the team's sponsor, tasked the group to create a mobile anatomically accurate model of the Circle of Willis. The model will allow tests to be conducted for Dr. Tim Becker's liquid embolic that will eventually treat cerebral aneurysms. The main goal is to select a clear material that will mimic vessel physiology, develop an accurate Circle of Willis structure, and ensure the existing instrumentation can be used by the model.

Multiple components are required to achieve this goal, one of them being calculating the stress experienced by the vessels and the material used will be able to handle the stress. Overall, the structure is thin walled in a pressurized environment with varying pressure experienced within the vessels from the blood being pumped to the brain. A hoop stress calculation will be used to find the stress experienced as well as existing experiential data for the Circle of Willis dimensions.

Assumptions:

The dimensions used for the Circle of Willis will be from data collected from research and will be used as average rather than a specific patient.

The pressure within the Circle of Willis vessels oscillates, so the highest pressure experienced for someone with an aneurysm is used in calculations, in this case being 170 mmHg [1]. The location of the aneurysm is not specified and will be assumed in a location where the 170mmHg pressure enables it's use.

Equations:

Hoop Stress equation will be used in the calculations

$$\sigma_H = \frac{Pd}{2t}$$

P – internal pressure (kPa)
d – cylinder inside diameter (mm)
t – wall thickness (mm)

Results:
Each section of the Circle of Willis was accounted for in regards to diameter [2], wall thickness [3[and the calculated hoop stress. With these results, a material can be selected that can handle the stress experienced on the tubes and the team can calculate a factor of safety which satisfies the client's requirements.

	Diameter (mm)	Wall thickness (mm)	Hoop Stress σ^t (kPa)
ACA-A1	2.33	0.25	105.61424
ACA-A2	2.4	0.25	108.7872
MCA	2.86	0.35	92.59862857
PCA-P1	2.13	0.3	80.4572
PCA-P2	2.1	0.3	79.324
ACoA	1.47	0.15	111.0536
PCoA	1.45	0.15	109.5426667
P(mmHg)=	170	max	
P(kPa)=	22.664	converted	

References

[1] Bloodpressureuk.org. (2008). Blood Pressure : Blood pressure chart. [online] Available at: http://www.bloodpressureuk.org/BloodPressureandyou/Thebasics/Bloodpressurechart [Accessed 21 Oct. 2017].

[2] Razavi, S. (2014). Numerical Simulation of the blood flow behavior in the circle of Willis. [online] PubMed Central (PMC). Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4097977/#R14 [Accessed 21 Oct. 2017].

[3] Moore, S., David, T., Chase, J., Arnold, J. and Fink, J. (2017). 3D models of blood flow in the cerebral vasculature. Journal of Biomechanics.