

Week 4: More Simulation and Tech Memo

Tuesday, September 20, 2022 6:40 PM

Objective: I plan to at least fill out the planning template, find sources, and start make relevant figures and simulations for the paper.

BME 214L Carotid Artery Simulation Planning

This document is to help you organize and plan your research, analysis, and writing your technical memorandum. There doesn't need to be a lot of wordiness on this document – just enough to collect the ideas you need to write about. You may need to add some lines to each of the tables below to capture everything needed. You should use a reference manager like Mendeley for this document so that you already have your research ready for the tech memo. Under the Reference column in each table, you can include the citation – just use IEEE [format](#)[1] so it's easy to read; at the bottom of the document, include your bibliography of all the sources you cited.

What are the medical concerns associated with carotid artery disease?

Concern	References
Stroke	[1]
TIA / Limb Shaking	[1]–[3]
Cognitive Impairment	[4]
Hypertension	[5]

List each of the concerns from your table above in the table below. For each concern, describe how the fluid mechanics either play a part in causing the problem, or how the fluid flow might be affected by the problem. Some of the medical concerns listed may not have much to do with fluid mechanics, so you can state that.

Concern	How fluid flow contributes or is impacted	References
Stroke	Blood flow dislodges plaque build-up and brings plaque to smaller vessels in the brain	[6]
TIA/ Limb Shaking	Repeated reduced blood flow to brain	[2]
Cognitive Impairment	Blockages lower blood flow, lowering mass flow to the brain, restricting necessary macromolecules for proper functioning from reaching the brain.	[7]
Hypertension	Plaque buildup makes the diameter of the space the blood can go through smaller so pressure increases	[5]

What are the specific fluid mechanics parameters that are associated with each concern you identified (velocity, pressure, mass flow rate, density, shear stress, etc)?

Concern	Fluid mechanics parameter	References
Stroke	Shear Stress	[8]
TIA	Pressure	[3]
Cognitive Impairment	Mass Flow Rate/Velocity	[7]
Hypertension	Pressure	[5]

For each fluid mechanic parameter listed above, what is the cutoff value between “OK” and “bad, we need to intervene”

Fluid mechanics parameter	Value or indication of a “bad” condition	References
Shear Stress	@Wall: Rupture: 56.2 +/- 30.6 Pa => > 55 Pa is concerning	[8]
Pressure	Over 140/90 mmHg = “bad”	[9], [10]
Mass Flow Rate	ICA: 351 ± 109 ml/min is severe => below 375 ml/min is concerning	[11]

For each fluid mechanic parameter listed above, what is the best way for you to evaluate or demonstrate how that parameter is impacted by the modeled blockages? Pick graphs, charts, tables, pictures, or something that best highlights those parameters for each of the different blood vessel geometries. Be very specific in your description (specific doesn't mean wordy; specific means sufficient detail). Envision figures that visibly and convincingly communicate that a blockage of a certain amount requires immediate repair.

Fluid mechanics parameter	Chart, table, graph used to demonstrate
Shear Stress	Surface plot, shear stress at wall only important.
Pressure	Surface plot, through all parts of the artery important
Mass Flow Rate	Cut plot, look at mass flow through ICA.

Bibliography

- [1] P. Sobieszczuk and J. Beckman, "Carotid Artery Disease," 2006, doi: 10.1161/CIRCULATIONAHA.105.542860.
- [2] M. Knoflach *et al.*, "Prognostic relevance of limb shaking in symptomatic carotid artery occlusion," *Cerebrovascular Diseases*, vol. 32, no. 1, pp. 35–40, Jul. 2011, doi: 10.1159/000326076.
- [3] S. Mazzucco *et al.*, "Cerebral hemodynamic effects of early blood pressure lowering after TIA and stroke in patients with carotid stenosis," *International Journal of Stroke*, 2022, doi: 10.1177/17474930211068655.
- [4] V. Demarin, I. Zavoreo, and V. B. Kes, "Carotid artery disease and cognitive impairment," *J Neural Sci*, vol. 322, no. 1–2, pp. 107–111, Nov. 2012, doi: 10.1016/J.JNS.2012.07.008.
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- [6] J. A. Madden, "Role of the vascular endothelium and plaque in acute ischemic stroke," *Neurology*, vol. 79, no. Issue 13, Supplement 1, pp. S58–S62, Sep. 2012, doi: 10.1212/WNL.0b013e3182695836.
- [7] S. Ogoh, "Relationship between cognitive function and regulation of cerebral blood flow," *The Journal of Physiological Sciences*, vol. 67, no. 3, pp. 345–351, May 2017, doi: 10.1007/s12576-017-0525-0.
- [8] K. Kojima *et al.*, "High Wall Shear Stress Is Related to Atherosclerotic Plaque Rupture in the Aortic Arch of Patients with Cardiovascular Disease: A Study with Computational Fluid Dynamics Model and Non-Obstructive General Angioscopy," *J Atheroscler Thromb*, vol. 28, no. 7, p. 742, Jul. 2021, doi: 10.5551/JAT.56598.
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- [10] Y. Shintani *et al.*, "Ambulatory blood pressure, blood pressure variability and the prevalence of carotid artery alteration: the Ohasama study," Lippincott Williams & Wilkins, 2007.
- [11] N. Ackroyd, R. Gill, K. Griffiths, G. Kossoff, and M. Appleberg, "Quantitative common carotid artery blood flow: Prediction of internal carotid artery stenosis," *J Vasc Surg*, vol. 3, no. 6, pp. 846–853, Jun. 1986, doi: 10.1016/0741-5214(86)90148-5.

Week 5: Simulation for Tech Memo

Wednesday, September 28, 2022 9:09 AM

Objective: Perform the simulations and change obstruction radius till each parameter is breached.

For each fluid mechanic parameter listed above, what is the cutoff value between "OK" and "bad, we need to intervene"

Fluid mechanics parameter	Value or indication of a "bad" condition	References
Sheer Stress	@Wall: Rupture: 56.2 +/- 30.6 Pa => > 55 Pa is concerning	[8]
Pressure	Over 140/90 mmHg = "bad"	[9], [10]
Mass Flow Rate	ICA: 351 ± 109 ml/min is severe => below 375 ml/min is concerning	[11]