3-Dimensional Cooling with a Catheter in a Carotid Bifurcation

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Objective

- To model the effects of cooling on a carotid bifurcation and predict the outlet temperatures when varying the flow rate of the common carotid artery.

Introduction

- **Stroke is one of the leading causes of death and disability in the world .**
- **Therapeutic hypothermia is a treatment to induce mild levels of hypothermia**
- **Rapidly induced localized mild hypothermia has proven benefits in reduction of tissue death [1] ,[2].**
- **Current treatments lack the ability to deliver rapid localized cooling to organs.**
- **A blood cooling system may synergize with current devices into a single tissue salvage solution.**
- **This combination has delivered rapid brain tissue cooling - up to 8° C in under 5 minutes during canine testing [3].**

Governing Comsol Equations

$$\rho(u\cdot\nabla)u=\nabla\cdot\left[-p\mathrm{I}+\mu(\nabla u+(\nabla u)^T)-\frac{2}{3}\mu(\nabla\cdot u)\mathrm{I}\right]+F$$

$$\nabla\cdot(\rho u)=0$$

$$\rho C_p u\cdot\nabla T=\nabla\cdot(k\nabla T)+Q+Q_{vh}+W_p$$

Boundary Conditions and Geometry

Boundary	Condition	Value
Artery Inlet	Mass Flow Rate	Varies
Catheter Inlet	Mass Flow Rate	2.65E-3 [kg/s]
ICA Outlet	Pressure No Viscous	0 [Pa]
ECA Outlet	Pressure No Viscous	0 [Pa]
Remaining Boundaries	No Slip	-
Artery Inlet Temperature	Temperature	310 [K]
Catheter Inlet/Wall Temperature	Temperature	301 [K]
Wall Temperature	Temperature	310 [K]
ICA & ECA Outflow	Outflow	-

Table 1: Boundary Conditions.

Geometry	Value(mm)
CCA Length	70.0
CCA Diameter	6.5
Catheter Length	5.0
Catheter Diameter	1.8
ICA Length	30.0
ICA Diameter	4.4
ICA Bulb Max Diameter	6.5
ECA Length	30.0
ECA Diameter	4.0
ICA/ECA Angle to CCA Centerline	25°

Table 2: Geometry values for final model.

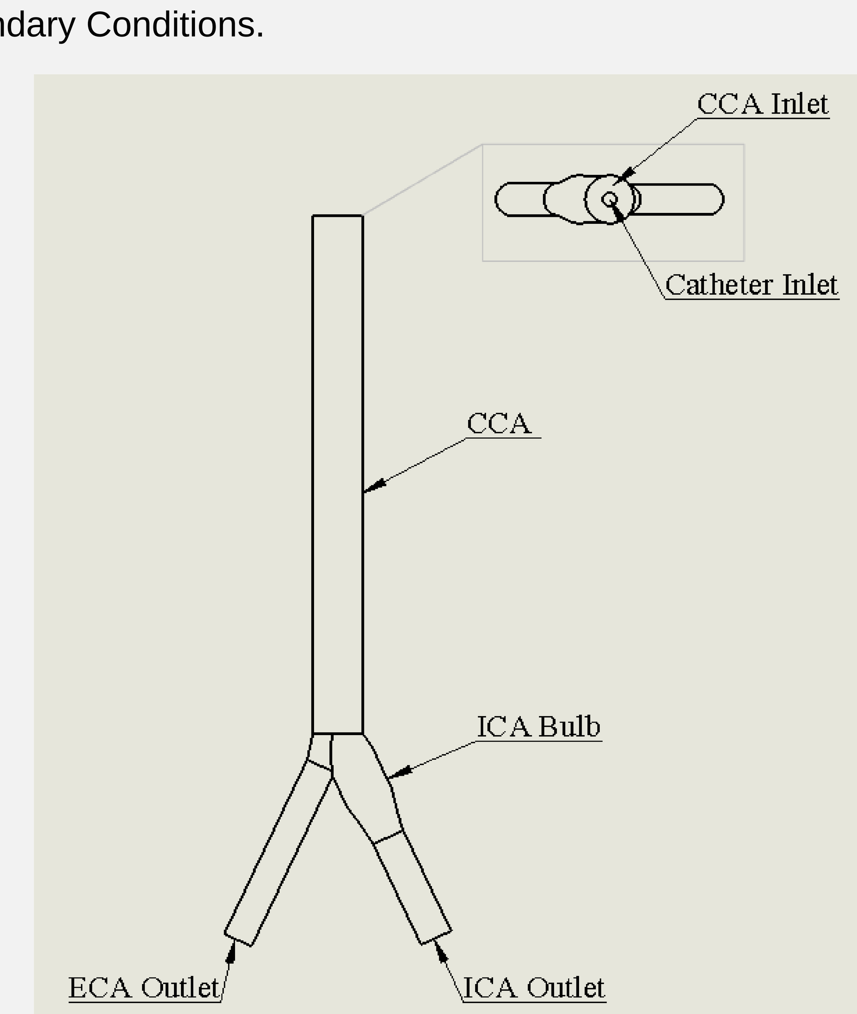

Fig. 1: Geometry values for final model.

Results

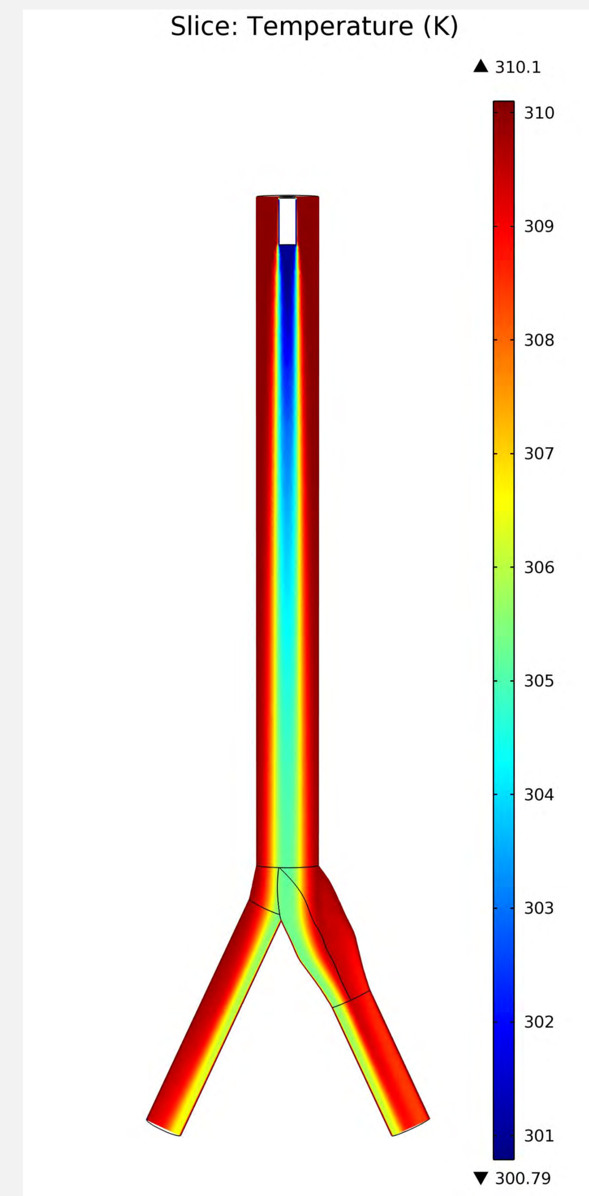

Fig. 2 Temperature of ECA outlet with two flow rates.

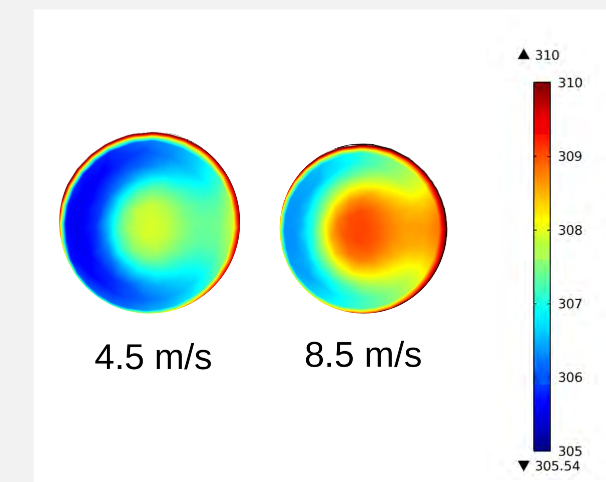

Fig 3. Temperature of ICA outlet with two flow rates.

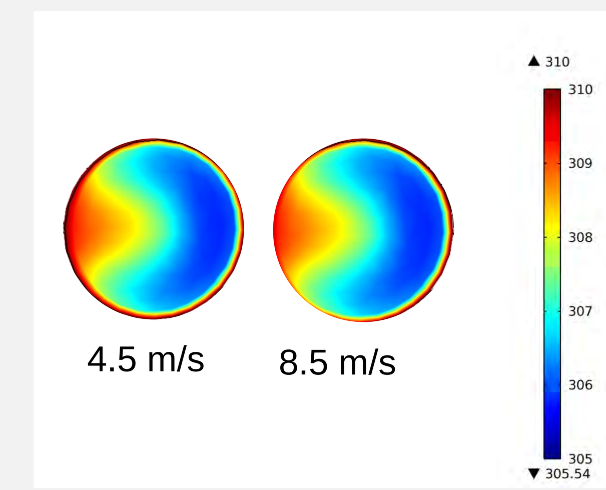

Fig. 4 Temperature of ECA outlet with two flow rates.

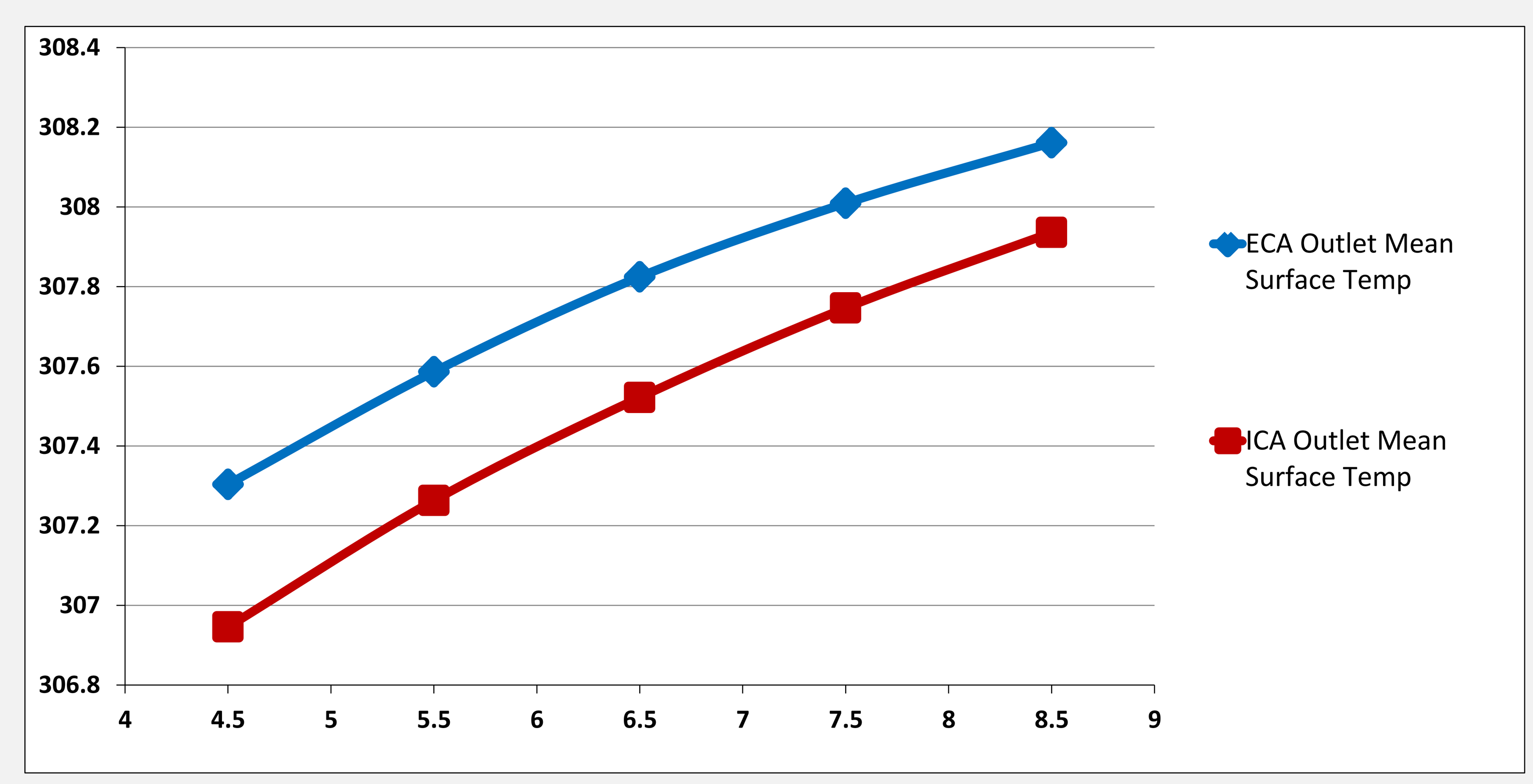

Fig. 5 Temperature of ICA and ECA outlet varied blood flow rates.

Conclusions and Future Work

- **Model shows a predicted decrease in cooling as artery blood flow rises**
- **Successfully predicts the outlet temperature in carotid bifurcation branches**
- **Will inform future more detailed carotid models and non constant surface temperature**
- **Future work to focus on pulsatile flow, heat transfer through tissue, more detailed model**
- **Final goal to predict thermal energy reduction of brain tissue with use of cooling catheter**

References

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3. Merrill, T.L., Akers, J., Merrill, D.R., Localized Brain Tissue Cooling For Use During Intracranial Thrombectomy, SBC2012-80833, American Society of Mechanical Engineering (ASME) 2012 Summer Biomedical Engineering Conference, Fajardo, Puerto Rico, June 20-23, 2012.

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