Simulating Thermotherapeutic Response Induced By Thermal Padding for Treating Acute Injuries

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Introduction: Cryotherapy and thermotherapy are common methods of treatment for acute injuries ranging from ankle sprains to complex surgery in order to control inflammation. Recently, the fluid-structure interaction was studied based on the arbitrary Lagrangian-Eulerian (ALE) technique [1]. In this work, we study the effect of induced temperature changes to vascularized tissue and the resulting blood flow fluctuation.

Computational Methods: The model geometry used in this work is shown in Fig. 1.

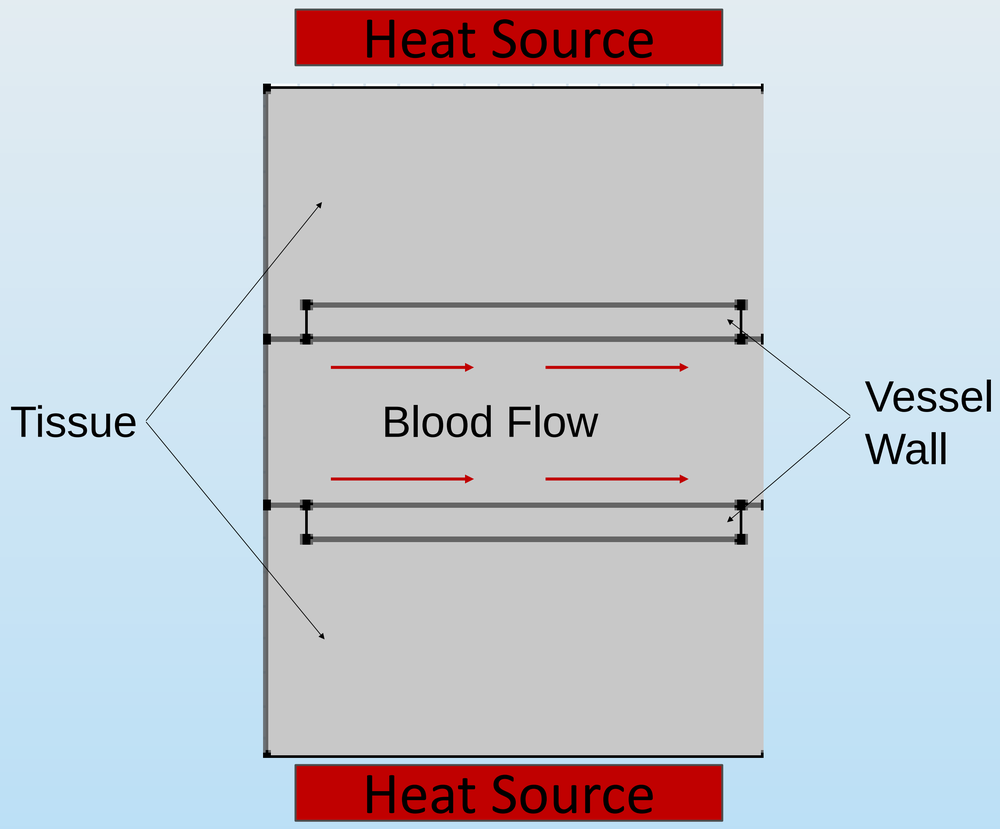

Figure 1. Schematic of Tissue Influenced by Temperature

The blood flow was taken into account by the incompressible Navier-Stokes equation

$$\rho\frac{\partial \boldsymbol{u}}{\partial t} - \nabla \cdot [p\boldsymbol{I} + n(\nabla \boldsymbol{u} + (\nabla \boldsymbol{u})^T] + \rho\big((\boldsymbol{u} - \boldsymbol{u}_m)\cdot\nabla\big)\boldsymbol{u} = \boldsymbol{F}$$
$$-\nabla \cdot \boldsymbol{u} = \boldsymbol{0}$$

The boundary load, $\mathbf{F}_{T,}$ experienced by the vessel walls is calculated by

$$\boldsymbol{F}_T = -\boldsymbol{n}\cdot(-p\boldsymbol{I} + n(\nabla u + (\nabla \boldsymbol{u})^T))$$

- The thermal stress is calculated by

$$-\nabla \cdot \sigma = Fv$$
$$\rho C_p \boldsymbol{u}_{trans}\cdot\nabla T = \nabla\cdot(k\nabla T) + Q$$

Results: The simulation results include the velocity and pressure of fluid flow and the thermal stress.

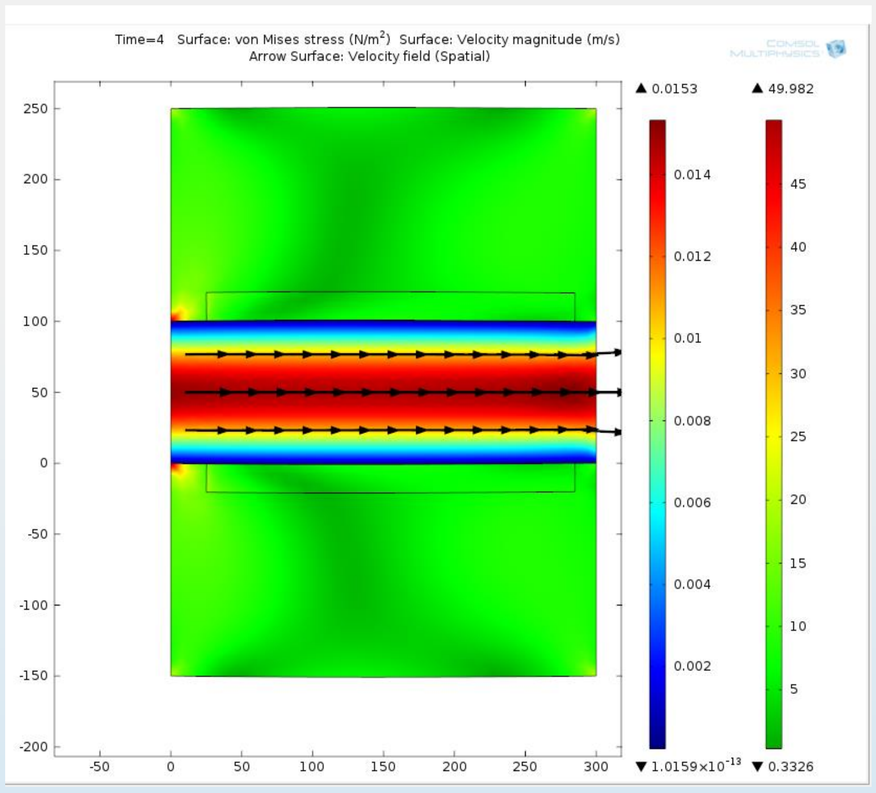

Figure 3. Vessel Fluid Flow

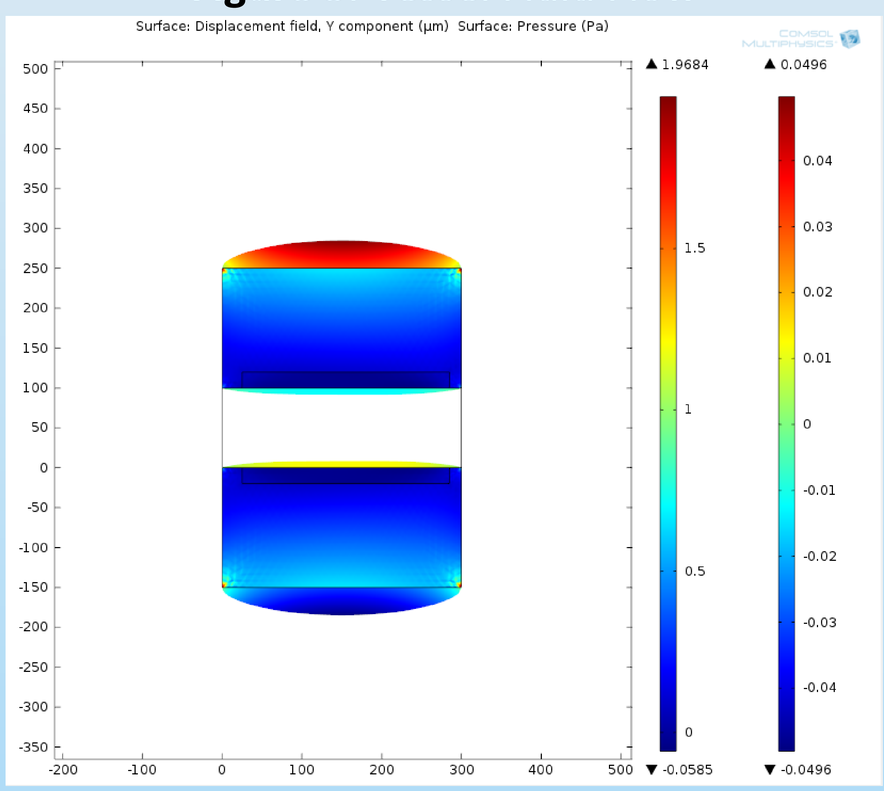

Figure 4. Heat Induced Displacement

Conclusions: This study presented the study of blood perfusion rates with respect to surrounding temperature. The calculations were performed for applied heat, which will allow for further improvement in inflammation control techniques.

Acknowledgements:

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References:

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2. Wesly, R. L., et al. "Static linear and nonlinear elastic properties of normal and arterialized venous tissue in dog and man." *Circulation research* 37.4: 509-520. (1975)
3. Jimenez Rios, Jorge L., and Yoed Rabin. "Thermal expansion of blood vessels in low cryogenic temperatures Part I: A new experimental device." *Cryobiology* 52.2 : 269-283. (2006)

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