Quantifying the Effect of Pulsatile Fluid Flow on Drug Distribution in the Spinal Canal

Timothy J. Harris Jr., Ying Hsu, Brian Sweetman, H.D.M. Hettiarachchi, Richard Penn MD, and Andreas A. Linninger
Laboratory for Product and Process Design
Department of Bioengineering, University of Illinois at Chicago
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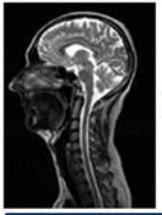
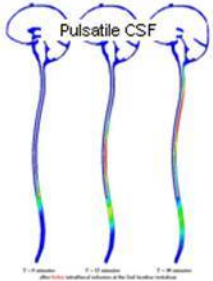
Drug Distribution in CNS After IT Bolus Infusion

From MRI imaging to computational modeling using first principles fluid mechanics





Equations

Continuity equation

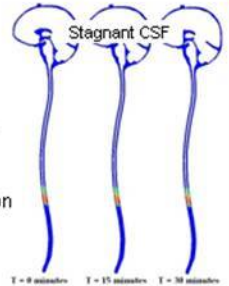
$$\nabla \cdot \vec{v} = 0$$

Navier Stokes equation

$$\frac{\partial}{\partial t}(\rho \vec{v}) + \nabla \cdot (\rho \vec{v}\vec{v}) = -\nabla p + \nabla \cdot (\bar{\bar{\tau}}) + \rho \vec{g} + \vec{F}$$

Species Transport equation

$$\frac{\partial C}{\partial t} + \vec{u}(x,t)\nabla C = \nabla D \nabla C + R$$

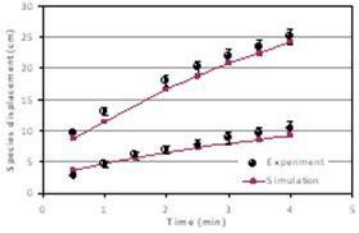


Motivation

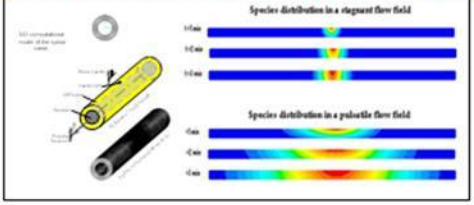
Intrathecal (IT) Delivery

- Bypasses blood brain barrier
- Delivers macromolecules to the brain tissue via the interconnected cerebrospinal fluid space
- Applications include proteins, nanoparticles and gene therapy using viral vectors

Experimental & Computational Validation



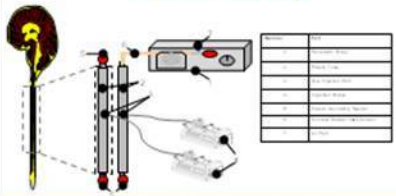
Computational Modeling of Spinal Canal with Cord



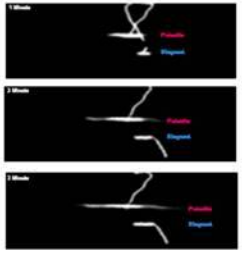
Future Work

Build three dimensional experimental and computational models to predict the outcome of IT treatment in the entire human CNS.

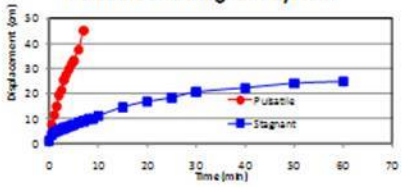
Experimental Set-Up



Nuclear Medicine Results



Distribution of Tc vs. Time in a Pulsatile and Stagnant System



Technetium-99m displacement with time for pulsatile and stagnant flow experiments. At seven minutes, pulsatile flow shows over 500% increase in displacement compared to stagnant flow experiments.