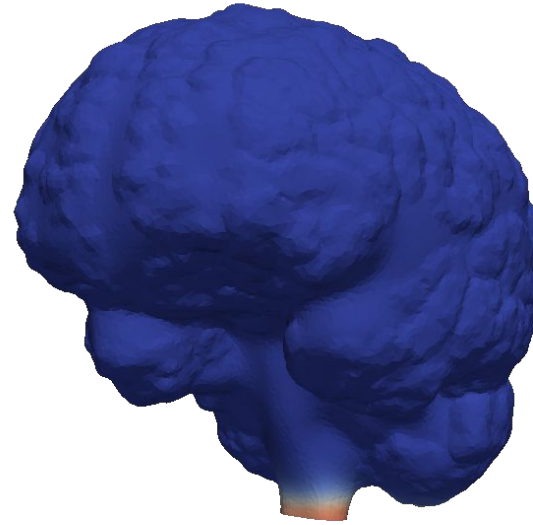


CSF circulation and dispersion yield rapid clearance from intracranial compartments

Martin Hornkjøl

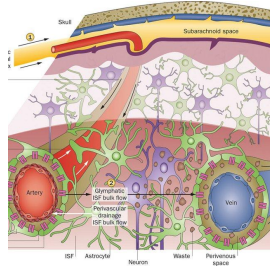
Department of Mathematics
University of Oslo

12/07/22

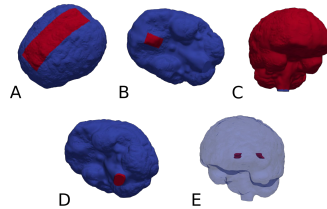


UiO : University of Oslo

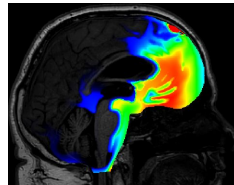
This presentation explores the effect CSF circulation on brain wide clearance



Waste clearance in the brain

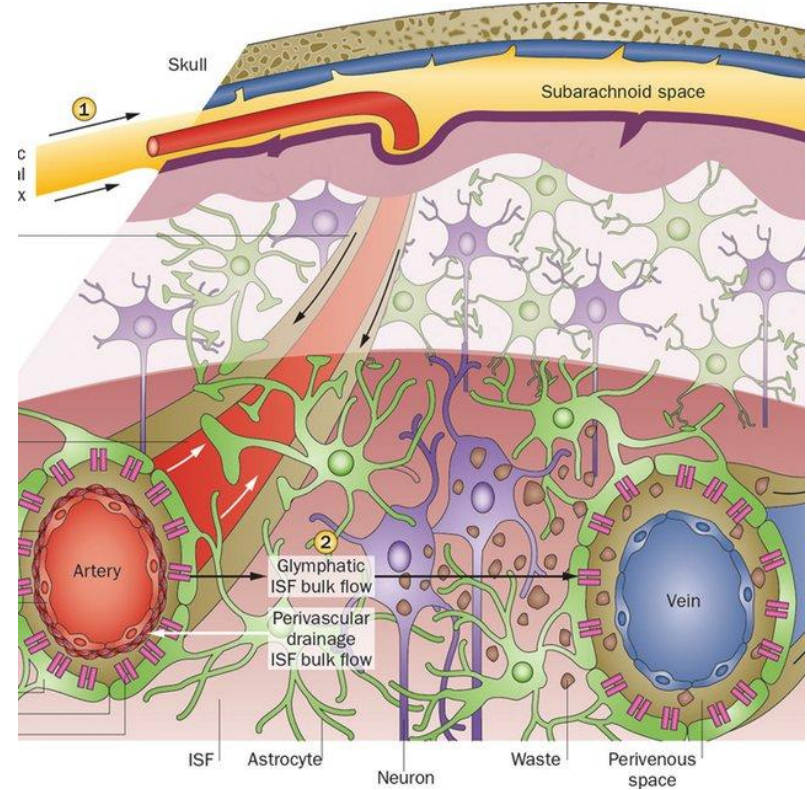


Different models

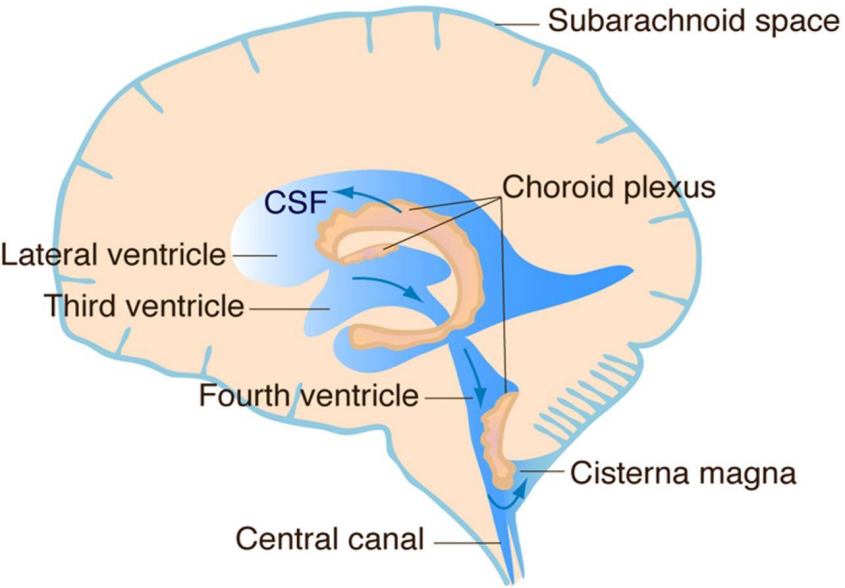


Results

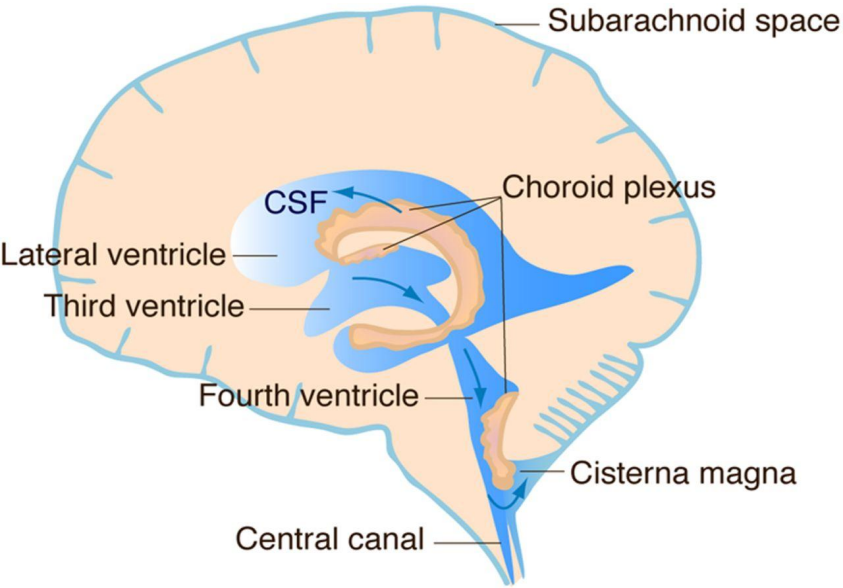
Waste is cleared from the brain by the flow of spinal fluid



Waste must further be cleared out of the fluid filled compartment surrounding the brain



Waste must further be cleared out of the fluid filled compartment surrounding the brain



Lehtinen et. al. 2013

Diffusion

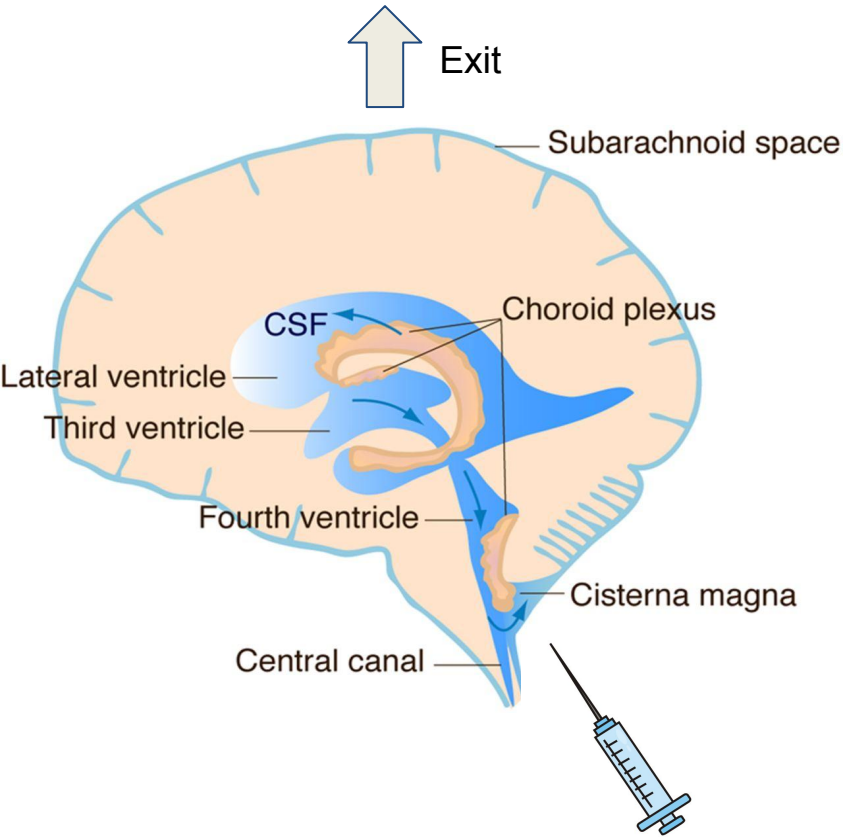


VS

Convection

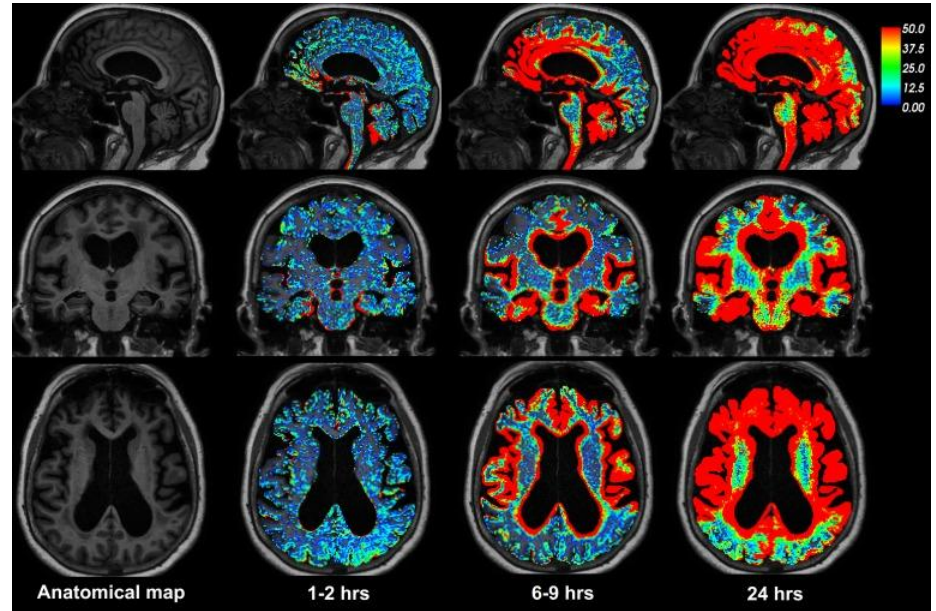
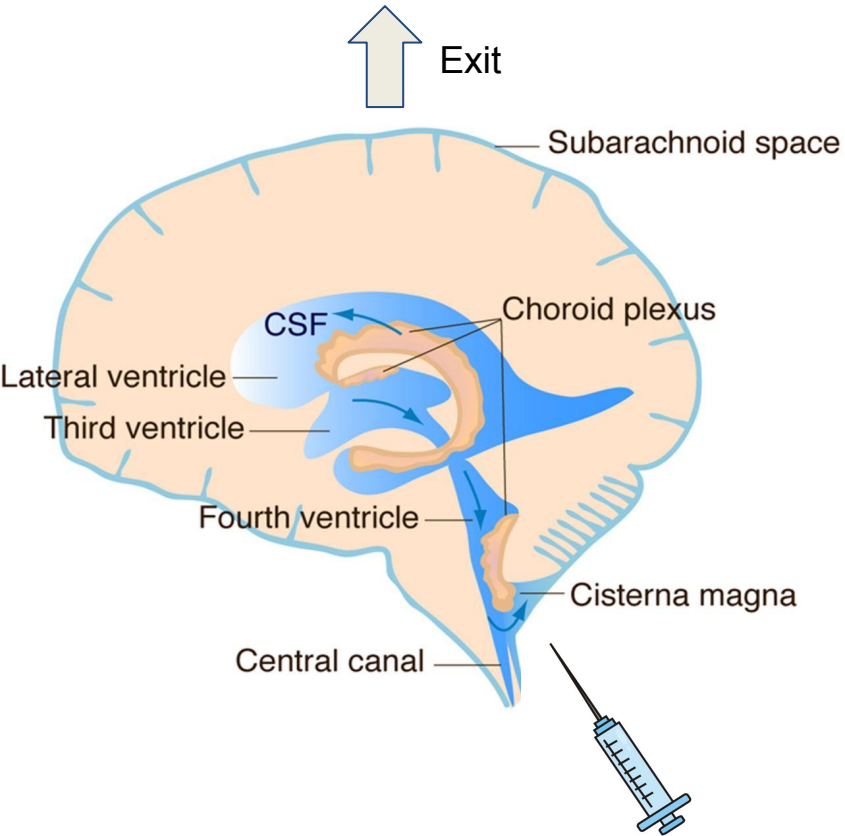


Medical studies have looked have looked at this



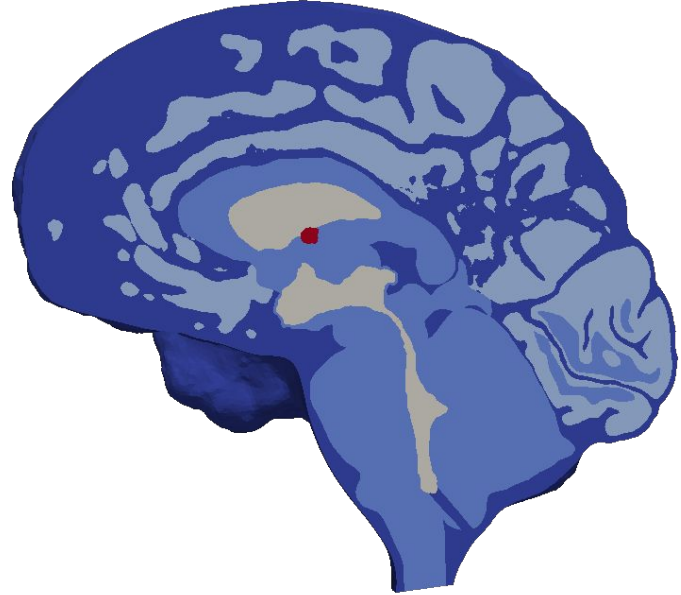
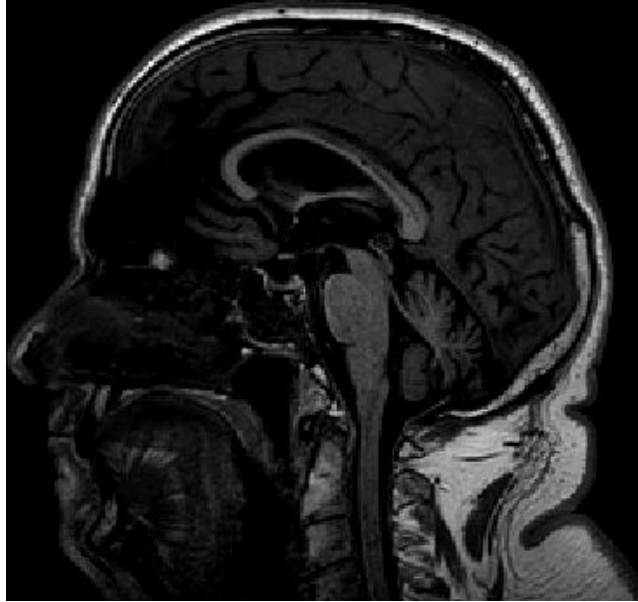
Experimental setup

Medical studies have looked have looked at this



Ringstad et. al. 2018

We run our simulations on meshes derived from patient MRI images



Modelling this circulation can give insight in what mechanisms drive clearance

Diffusion

$$\phi \frac{\partial c}{\partial t} - \nabla \cdot (\phi \alpha D \nabla c) = 0$$

Convection-diffusion

$$\phi \frac{\partial c}{\partial t} + \phi u \cdot \nabla c - \nabla \cdot (\phi \alpha D \nabla c) = 0$$

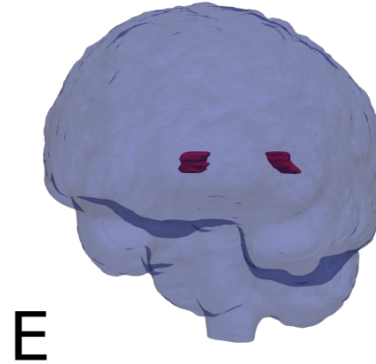
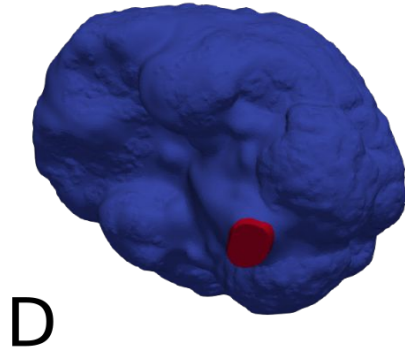
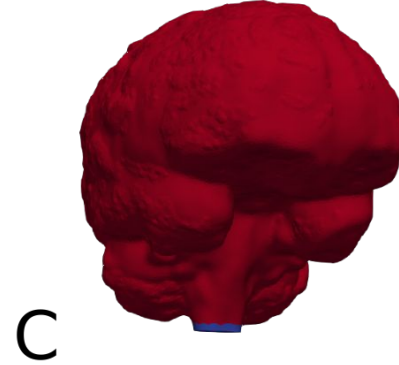
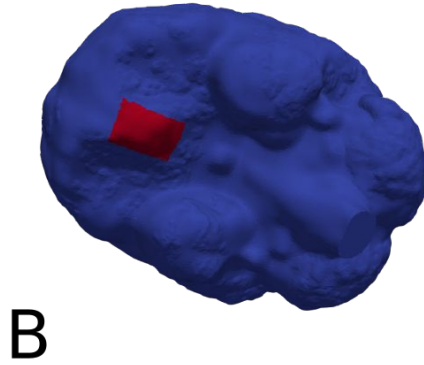
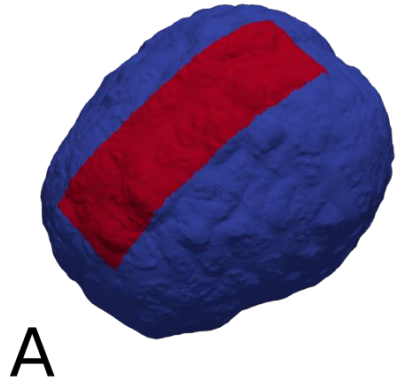
**The velocity is calculated with the steady state
Stokes equation in the CSF space**

$$\mu \nabla^2 u - \nabla p = 0 \quad \text{in } \Omega_F$$

We looked at 6 models with different parameters

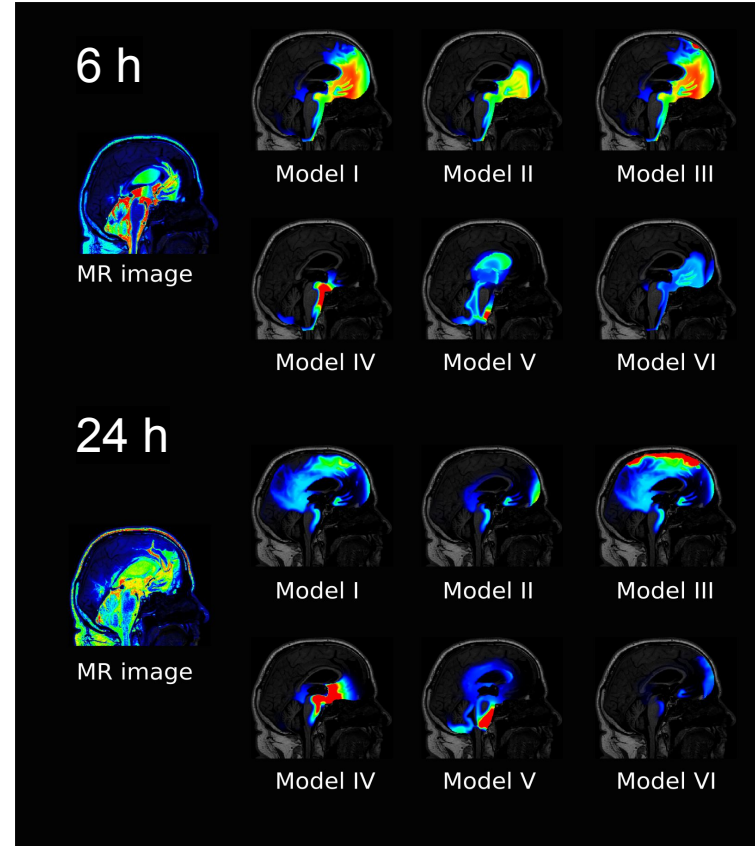
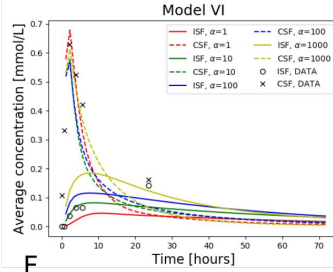
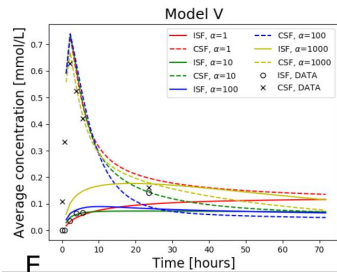
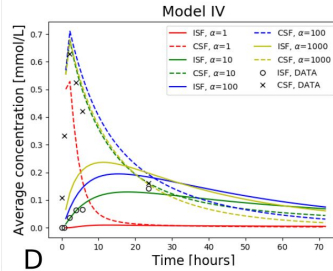
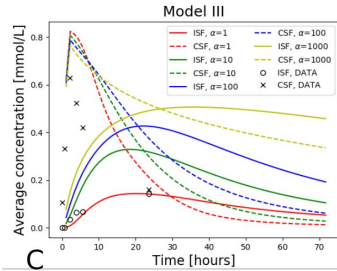
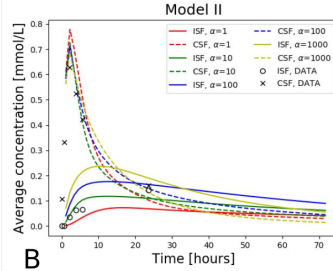
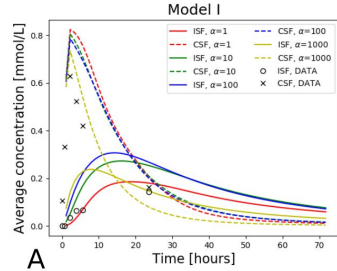
Model	Production site	Absorption site	R_0 (Pa/(mm s))	β (mm ² /s)	Production (L/day)
I	Choroid plexus	Parasagittal dura	0	∞	0.5
II	Choroid plexus	Cribriform plate	0	∞	0.5
III	Choroid plexus	Parasagittal dura	0	10^{-4}	0.5
IV	Choroid plexus	meningeal lymphatics	10^{-5}	10^{-4}	0.5
V	Foramen magnum	Choroid plexus	0	∞	0.5
VI	Choroid plexus	Cribriform plate	0	∞	1.0

We looked at 6 models with different parameters



**Diffusion alone is too slow to explain
observations**

Clinical Data can be explained by convective flow in the CSF spaces without the need of flow in the ISF



Thanks to my collaborators



Vegard Vinje



Marie Rognes



Kent-Andre Mardal



Lars Magnus Valnes



Geir Ringstad



Per Kristian Eide