The 18th International Conference on Finite Elements in Flow Problems (FEF2015)
16-18 March 2015, Taipei, Taiwan

Understanding Hydrocephalus using Multicompartmental Poroelasticity

John C. Vardakis[1,2], Dean Chou[1*], and Yiannis Ventikos[2]

[1] Institute of Biomedical Engineering and Department of Engineering Science,
University of Oxford, Oxford, OX1 3PJ, United Kingdom
john.vardakis@eng.ox.ac.uk and dean.chou@eng.ox.ac.uk
[2] Department of Mechanical Engineering,
University College London, Torrington Place, London, WC1E 7HB, United Kingdom
y.ventikos@ucl.ac.uk

Key Words: *Cerebrospinal fluid, Hydrocephalus, Multiple-network Poroelastic Theory*

Cerebral tissue and related transport phenomena in the brain combine a number of characteristics that make their theoretical and computational representation and analysis particularly challenging: the brain has extreme metabolic and oxygenation needs but with minimal capacity to store glucose and oxygen, it is perfused by a markedly complex vascular system, it produces and floats in cerebrospinal fluid which is in continuous exchange with vascular plasma and – enclosed in the cranium – is probably the most inaccessible organ in the human body.

We propose a novel multiscale approach for addressing these modelling challenges that involves the representation of cerebral tissue as a poroelastic medium permeated by a multiplicity of passages (Multiple-network Poroelastic Theory) – each with its own features (for instance, porosity and permeability) These networks have the potential to communicate with each other, according to predefined transport laws. We apply this new modelling framework to the case of hydrocephalus – a disease that is equally important and paradoxical. Hydrocephalus can be succinctly described as the abnormal accumulation (imbalance between production and circulation) of cerebrospinal fluid within the brain. Using hydrocephalus as a test bed, one is able to account for the necessary mechanisms involved in the interaction between cerebral fluid production, transport and drainage. The model is discretised in a variety of formats, through the established finite difference method, finite difference – finite volume coupling and also the finite element method. Both chronic and acute hydrocephalus was investigated in a variety of settings, and accompanied by emerging surgical techniques where appropriate.