MULTI-SCALE MODELS OF FLUID TRANSPORT IN THE BRAIN

Xi Chen[1], Tamas I. Jozsa[1] and Stephen J. Payne[2*]

[1] Institute of Biomedical Engineering, Department of Engineering Science, University of Oxford, Oxford, UK, xi.chen2@st-hildas.ox.ac.uk, tamas.jozsa@eng.ox.ac.uk

[2] Institute of Applied Mechanics, National Taiwan University, Taipei, Taiwan, stephenpayne@ntu.edu.tw

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Many processes in the brain are governed by the transport of fluids and the resulting interaction with brain tissue. To understand these fully, a multi-scale approach has to be adopted in order to simulate the processes that occur at both the cellular level and the tissue level. This is of particular importance in pathophysiology when dysfunction at the cellular level is translated to changes in the properties of the tissue. In our previous work, Mokhtarudin and Payne (2017), we examined the transport of water through water-protein channels and quantified the effects of transport at the cellular length scale on the tissue length scale in the context of brain oedema.

We have now extended our work to examine the effects of water transport through the use of a multi-compartment model that enables us to couple our transport model with a whole-brain perfusion model, Jozsa et al. (2021). The link between the two is provided through a model of the breakdown of the blood-brain-barrier (BBB), that is known to occur in response to ischaemia. This combined framework can thus be utilised to improve clinical planning and treatment by extending existing ischaemic stroke models considering both intracranial pressure and tissue displacement changes in patients. This model can also be used to consider haemorrhagic transformation in the future through coupling with our other work, Wang and Payne (2021).

We will present the results from this novel coupled model and evaluate the importance of the different parameters by conducting sensitivity analysis. The model will be applied in the context of reperfusion studies for ischaemic stroke patients, where it is known that vasogenic and cytotoxic oedema can play an important role in determining the final patient outcome. We will present a route to proper model validation through the use of large patient databases that have been made available through the INSIST project and the MRCLEAN dataset.

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