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Modelling Brain Temperature and Perfusion for Cerebral Cooling

STEPHEN BLOWERS, PRASHANT VALLURI, Institute of Materials and Processes, University of Edinburgh, IAN MARSHALL, Neuroimaging Sciences, Centre for Clinical Brain Sciences, University of Edinburgh, PETER ANDREWS, BRIDGET HARRIS, Critical Care Unit, NHS Lothian, Centre for Clinical Brain Sciences, University of Edinburgh, MICHAEL THRIPPLETON, Neuroimaging Sciences, Centre for Clinical Brain Sciences, University of Edinburgh — Brain temperature relies heavily on two aspects: i) blood perfusion and porous heat transport through tissue and ii) blood flow and heat transfer through embedded arterial and venous vasculature. Moreover brain temperature cannot be measured directly unless highly invasive surgical procedures are used. A 3D two-phase fluid-porous model for mapping flow and temperature in brain is presented with arterial and venous vessels extracted from MRI scans. Heat generation through metabolism is also included. The model is robust and reveals flow and temperature maps in unprecedented 3D detail. However, the Karmen-Kozeny parameters of the porous (tissue) phase need to be optimised for expected perfusion profiles. In order to optimise the K-K parameters a reduced order two-phase model is developed where 1D vessels are created with a tree generation algorithm embedded inside a 3D porous domain. Results reveal that blood perfusion is a strong function of the porosity distribution in the tissue. We present a qualitative comparison between the simulated perfusion maps and those obtained clinically. We also present results studying the effect of scalp cooling on core brain temperature and preliminary results agree with those observed clinically.

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