Modelling of Drug Delivery via Infusion into Multiphasic Brain Tissue

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ABSTRACT: A direct intracranial infusion of a therapeutical solution into the extra-vascular space of human brain tissue represents a promising medical application for the effective treatment of malignant brain tumours. With the desire to support the practising surgeon pre-operatively with numerical studies, a macroscopic continuum-mechanical model is established within the Theory of Porous Media (TPM). Proceeding from a volumetric homogenisation of the underlying micro-structure, the ternary model consists of an elastically deformable solid skeleton (compound of tissue cells and vascular walls), which is perfused by two separated liquid phases, the blood plasma and the overall interstitial fluid. The latter is treated as a binary mixture of two components, namely, the liquid solvent and the dissolved therapeutic solute. This yields a model with four constituents. After the completion of the governing balance equations with admissible constitutive relations, the strongly coupled solid-liquid transport problem is simultaneously approximated in all primary unknowns using mixed finite elements (uppc-formulation) and solved in a monolithic manner with an implicit Euler time-integration scheme. Numerical examples show the irregular spreading of infused drugs in the inhomogeneous and anisotropic white-matter tracts of human brain tissue and further occurring effects beyond.