Multiscale Modelling of 3-Dimensional Brain Tissue with Capillary Distribution

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ABSTRACT

Existing brain model has been developed to study brain oedema formation in ischaemic stroke, assumed the brain as a homogenized structure and ignored the effects of blood capillary of the brain. Thus, the aim of this study is to reconsider the effects of capillary in the brain model through multiscale approach using asymptotic expansion homogenization (AEH) technique. AEH is applied to the existing governing equations of the brain, resulting in new governing equations consist of 6 homogenized macroscale equations and 4 microscale cell problems. Actual brain capillary geometry is developed based on actual capillary network distribution data generated using modified spanning tree method. The microscale cell problems are then solved in actual brain capillary geometry in order to obtain four important parameters, namely the hydraulic conductivity, homogenous Biot's coefficient and elastic stiffness tensor. From the result, the distribution matrix obtained for hydraulic conductivity is not isotropic. This problem can be improved by increasing the volume of the actual capillary geometry. For homogenous Biot's coefficient, the matrix obtained is isotropic, however the reliability of the result obtained can be improved by solving the cell problem in multiple capillary geometries. For elastic stiffness tensor, it can be concluded that this parameter does not significantly affected the macroscale equations of bigger brain. All these parameters are required later in order to solve the homogenized macroscale equations for the investigation of brain diseases such as ischaemic stroke and dementia.

KEYWORDS: actual capillary geometry, ischaemic stroke, asymptotic expansion homogenization, macroscale equations, microscale cell problems

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