A Fully Dynamic Multi-Compartmental Poroelastic System: Application to Aqueductal Stenosis

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This study proposes the implementation of a fully dynamic quadriphasic poroelastic model which is underpinned by multiple-network poroelastic theory (MPET), in order to account for the effects of varying stages of aqueductal stenosis and atresia during acute hydrocephalus. The innovation of the fully dynamic MPET implementation is that it avoids the commonplace assumption of quasi-steady behaviour; instead it incorporates all transient terms in the casting of the equations and in the numerical solution of the resulting discrete system.

It was observed that the application of mild stenosis allows for a constant value of amalgamated ventricular displacement in under 2.4 hours, whereas the application of a severe stenosis delays this settlement to approximately 10 hours. A completely blocked aqueduct does not show a clear sign of reaching a steady ventricular displacement after 24 hours. The increasing ventricular pressure (complemented with ventriculomegaly) during severe is causing the trans-parenchymal tissue region to respond, and this coping mechanism is most attenuated at the regions closest to the skull and the ventricles. After 9 hours, the parenchymal tissue shows to be coping well with the additional pressure burden, since both ventriculomegaly and ventricular CSF pressure show small increases between 9 and 24 hours. Localised swelling in the periventricular region could also be observed through a CSF fluid increment, whilst dilation results showed stretch and compression of cortical tissue adjacent to the ventricles and skull.

Keywords: Multiple-Network Poroelastic Theory, Hydrocephalus, Aqueduct, Cerebrospinal Fluid, Stenosis