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A multiphase model of glioblastoma multiform onset and growth

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Patients diagnosed with glioblastoma multiforme (GBM) are expected to survive only 14 months and die due to the pressure that the tumour builds in the brain as well as the formation of peritumoural edema (PTE). With the view to investigating the early stages of brain tumour development, and how it impacts the healthy brain environment, we develop a mechanistic model of GBM onset. The model is derived using principles of mass and momentum balances and explicitly includes pressure dynamics within the disease brain and the ability/inability of healthy tissue to repair itself in response to these cues. As a first step we assume an implicit tumour that exerts pressure at a healthy boundary causing the boundary to move into healthy tissue with a velocity v (thought of as the tumour growth rate). We investigate three velocity regimes: where v is an order of magnitude slower than the time-scale of healthy brain tissue renormalization (benign tumour); where v is an order of magnitude higher than the time-scale of healthy brain tissue renormalization (high grade tumour); a transition between these where v is the same magnitude as the time-scale of healthy brain tissue renormalization. Our model shows a correlation between the tumour velocity and the formation of PTE, which is an indicator of tumour malignancy. The resulting model includes time-varying diffusion on a moving domain, which presents unique numerical challenges. We propose a scheme to solve such equations, validating our method with a test problem as well as theoretical analysis using techniques from asymptotic methods in order to complete this research aim.

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