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Modelling brain tumour recurrence patterns following surgical resection with ischemia

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Glioblastoma Multiforme (GBM) is the most aggressive primary brain tumour, with a median life expectancy of only 15 months with treatment. Although surgical resection is a standard-of-care procedure, the migratory nature of the tumour cells limits its efficacy as not all tumour cells can be removed. The tumour will usually re-establish itself along the resection cavity wall, known as a local recurrence, but it can recur elsewhere or become more migratory, known as a distal recurrence. Clinical data has shown that patients with ischemia following resection are more likely to have a distally recurring tumour, with an incidence rate of 61% for those with ischemia vs 19% for those without. This evidence suggests that a lack of nutrients plays a role in the tumour recurrence pattern but does not fully answer the question regarding the difference between tumours that do or do not recur distally under these conditions.

We present the Proliferation Invasion Hypoxia Necrosis Angiogenesis (PIHNA) model that simulates the angiogenic cascade of a GBM as it grows. We have applied this mechanistic model to show how an in silico GBM grows following resection and subsequent ischemia, and to highlight the role of the individual tumour kinetics in this behaviour. Our simulations suggest that the diffusivity of the tumour, the tumour cell proliferation rate, and the hardiness of the cells all play key roles in the recurrence location of a GBM.

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