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Modelling cycling hypoxia by multiple equilibria of non-Newtonian blood flow through vascular networks[1] GEORGE ATKINSON, PHILIP MAINI, ESTER HAMMOND, JOE PITT-FRANCIS, HELEN BYRNE, University of Oxford — The presence of regions of insufficient oxygen, or hypoxia, within tumours can significantly impact patient responses to therapy. Furthermore, experimental results have shown that transient periods of cycling hypoxia can select for more therapy-resistant and invasive tumours. A useful metric for quantifying hypoxia is the haematocrit distribution in the tumour micro-circulation. We model the haematocrit distribution within a vessel network by coupling steady state equations for flow through individual vessels with phenomenological rules for haematocrit splitting at vessel bifurcations. These equations are constructed to guarantee that the volumetric flow of blood and red blood cells are conserved at vessel junctions. We hypothesis that these equations admit multiple solutions and that cycling hypoxia can be generated by stochastic fluctuations between these solutions. To facilitate the identification and enumeration of the model solutions, we propose algebraic approximations to the equations of flow and haematocrit splitting. Under these approximations, the governing equations reduce to an algebraic nonlinear system which can be analyzed using homotopic continuation, guaranteeing that all model solutions are identified. This allows for finding the solutions of larger microvascular networks that are not possible to solve directly.

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