Zheng, X.; **Wise, S. M.**; **Cristini, V.**

Nonlinear simulation of tumor necrosis, neo-vascularization and tissue invasion via an adaptive finite-element/level-set method. (English) Zbl 1334.92214

Bull. Math. Biol. 67, No. 2, 211-259 (2005).

Summary: We present a multi-scale computer simulator of cancer progression at the tumoral level, from avascular stage growth, through the transition from avascular to vascular growth (neo-vascularization), and into the later stages of growth and invasion of normal tissue. We use continuum scale reaction-diffusion equations for the growth component of the model, and a combined continuum-discrete model for the angiogenesis component. We use the level set method for describing complex topological changes observed during growth such as tumor splitting and reconnection, and capture of healthy tissue inside the tumor. We use an adaptive, unstructured finite element mesh that allows for finely resolving important regions of the computational domain such as the necrotic rim, the tumor interface and around the capillary sprouts. We present full nonlinear, two-dimensional simulations, showing the potential of our virtual cancer simulator. We use microphysical parameters characterizing malignant glioma cells, obtained from recent in vitro experiments from our lab and from clinical data, and provide insight into the mechanisms leading to infiltration of the brain by the cancer cells. The results indicate that diffusional instability of tumor mass growth and the complex interplay with the developing neo-vasculature may be powerful mechanisms for tissue invasion.

MSC:

92C50 Medical applications (general)

65M60 Finite element, Rayleigh-Ritz and Galerkin methods for initial value and initial-boundary value problems involving PDEs

Keywords:

tumor necrosis; neo-vascularization; tumor splitting; finite element mesh

Full Text: DOI