Isogeometric simulations of glioma growth on precise brain geometries based on the proliferation-invasion-hypoxia-necrosis-angiogenesis model.

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ABSTRACT

Cancer is one of the leading causes of death worldwide. Gliomas are tumors that originate from astrocytes, the cells that make up the supportive tissue of the brain. In particular, glioblastomas are a type of glioma that are highly malignant, because their tumoral cells reproduce quickly and are supported by a large network of blood vessels. Glioblastomas can be identified in biopsies, computed tomography scans, and magnetic resonance images by the presence of increased microvasculature, mitosis, and necrosis. These features can be used to validate mathematical models that have attempted to simulate glioblastoma growth, such as [1].

The aim of this research is to develop a mathematical model to simulate this phenomenon. Our proposal is based on the proliferation-invasion-hypoxia-necrosis-angiogenesis model [2] with a given initial tumor size and shape, on a domain that represents the patient's brain anatomy. This model, valid for 2D and 3D, distinguishes between grey and white matter in terms of invasion rate and employs the phase-field method to account for the geometry of the brain. Diffusion-reaction equations were used to compute normoxic, hypoxic, and necrotic cell density, microvasculature proliferation, and production of diffusible angiogenic factors.

We performed simulations by means of Isogeometric Analysis [3], using a NURBS basis to accurately and efficiently compute tumor growth. The results could be used to predict clinical outcome, design optimal patient-specific therapies, estimate life expectancy of untreated patients, or the simulation of the effects of surgery.

REFERENCES

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