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Chemotherapeutic drug transport to brain tumor.

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Implantation of polymeric wafers to deliver a chemotherapeutic drug is the most popular strategy against a brain tumor, but the understanding on local drug transport to influence the treatment efficacy is often overlooked. In this work, we employ a computational fluid dynamics simulation to study the suitability of four chemotherapeutic agents from a transport perspective, which specifically are carmustine, paclitaxel, 5-fluorouracil (5-FU), and methotrexate (MTX). The study is based on the diffusion/reaction/convection model, in which Darcy's law is used to account the convective contribution of the interstitial fluid. A realistic three-dimensional (3D) tissue geometry is extracted from magnetic resonance images (MRI) of a brain tumor. Our analysis explains how the distribution of the drug in the brain tumor is sensitively coupled to its physico-chemical properties. For the postulated conditions, only paclitaxel exhibits minimal degradation within the cavity: its effective cavity concentration is at least two times higher than those of others. It also exhibits the best penetration of the remnant tumor, so that the tumor is exposed to higher effective concentration up to two orders of magnitude as compared to others. It is also found that tumor receives uneven distribution of drug concentration, in which, even paclitaxel fails to provide adequate penetration on that part of the cavity surface nearest to the ventricles. In addition, we consider antiangiogenic treatment, which has been postulated to be a way to avoid drug loss from the treatment region by convection. It is shown that convection is of only marginal importance and that renormalization has little effect.

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