

Three-Dimensional Simulation of *Carmustine* Delivery to a Patient-Specific Brain Tumor

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Abstract—This study presents the recent development of three-dimensional patient-specific simulation of *carmustine* delivery to brain tumor that highlights several crucial factors affecting the delivery. The simulation utilizes the full-brain three-dimensional geometry constructed from magnetic resonance images (MRI) of a brain tumor patient. Prior to the simulation with tumor, the baseline simulation is initially done to obtain the interstitial fluid homeostasis in the normal brain so that the real picture of brain fluid dynamics in human brain is obtained. The simulation is conducted by coupling equations of continuity, motion, and *carmustine* species conservation, which, in turn, are solved simultaneously to calculate pressure, flow, and drug concentration fields, respectively. *Carmustine* is delivered by using the commercially available “Gliadel” wafers following the surgical removal of the tumor. The possible effects of vasogenic edema (due to surgery trauma) to brain fluid dynamics is also included. Here, the compiled results highlight that the drug release profile is, if not more than, as important as the dosage and the possible increase of convection due to edema. This study also reveals that a new strategy, namely convection enhanced delivery (CED) is able to increase drug penetration by enhancing interstitial fluid convection;

but, over-enhanced convection may cause toxicity complications to surrounding healthy tissue during later stages of treatment.