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Chemotherapeutic Drug Cytotoxicity Measurement with a 3D Biomimetic Microfluidic Device and Computational Fluid Dynamics Model

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Computational modeling of the effect of interstitial electroosmotic flow and electrophoretic movement of the paclitaxel drug on triple negative breast cancer fraction killed

The chemotherapeutic resistance due to the tumor microenvironment heterogeneity and the tumor extracellular matrix is the challenge for effective drug delivery into the tumor. Application of electric field can overcome some of these barriers. Electrotherapy treatments such as electro chemotherapy which is based on electroporation phenomena is a promising treatment to overcome the cell membrane barrier against drug delivery. The electroporation side effects include the disorganization of the stratum corneum, the toxicity of pH changes, and the cell viability decreasing. However, the iontophoresis treatment for targeted chemotherapeutics delivery via the blood stream using electric current can give us a better result and less side effects due to the external electrode applied to the skin for accessible solid tumors such as breast cancer. To develop the effectiveness of iontophoresis treatment, a fundamental, mechanistic understanding of the underlying physical phenomena governing tumor response to interstitial electroosmotic flow and electrophoretic movement of the chemotherapeutics remains elusive. Therefore, the overarching research goal of the proposed work is to develop a computational model based on fundamental principles to describe the electrical field effects in combination with chemotherapy and validate the model with the proposed *in vitro* experiment. In this study, the COMSOL Multiphysics simulation tool is used to solve a coupled electroosmotic flow and mass transfer in porous media. This simulation facilitates the design optimization of a novel microfluidic device to carry out the in-vitro experiment for the improved computational model validation. We have simulated the novel microfluidic device to study the effect of electrokinetics phenomena on paclitaxel drug transport in the porous media. The outcome of the improved computational model can predict the effectiveness of iontophoresis on triple negative breast cancer fraction killed.