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Drug Delivery to Solid Tumor: Effect of Dynamic Capillary Network Induced by Tumor

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Abstract : The computational methods provide condition for investigation related to the process of drug delivery, such as convection and diffusion of drug in extracellular matrices, and drug extravasation from microvascular. The information of this process clarifies the mechanisms of drug delivery from the injection site to absorption by a solid tumor. In this study, an advanced numerical method is used to solve fluid flow and solute transport equations simultaneously to show how capillary network structure induced by tumor affects drug delivery. The effect of heterogeneous capillary network induced by tumor on interstitial fluid flow and drug delivery is investigated by this multi scale method. The sprouting angiogenesis model is used for generating capillary network induced by tumor. Fluid flow governing equations are implemented to calculate blood flow through the tumor-induced capillary network and fluid flow in normal and tumor tissues. The Starling's law is used for closing this system of equations and coupling the intravascular and extravascular flows. Finally, convection-diffusion-reaction equation is used to simulate drug delivery. The dynamic approach which changes the capillary network structure based on signals sent by hemodynamic and metabolic stimuli is used in this study for more realistic assumption. The study indicates that drug delivery to solid tumors depends on the tumor induced capillary network structure. The dynamic approach generates the irregular capillary network around the tumor and predicts a higher interstitial pressure in the tumor region. This elevated interstitial pressure with irregular capillary network leads to a heterogeneous distribution of drug in the tumor region similar to in vivo observations. The investigation indicates that the drug transport properties have a significant role against the physiological barrier of drug delivery to a solid tumor.

Keywords : solid tumor, physiological barriers to drug delivery, angiogenesis, microvascular network, solute transport
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