Predicting the electric field distribution in the brain for the treatment of glioblastoma.

Miranda PC, Mekonnen A, Salvador R, Basser PJ.

Abstract
The use of alternating electric fields has been recently proposed for the treatment of recurrent glioblastoma. In order to predict the electric field distribution in the brain during the application of such tumor treating fields (TTF), we constructed a realistic head model from MRI data and placed transducer arrays on the scalp to mimic an FDA-approved medical device. Values for the tissue dielectric properties were taken from the literature; values for the device parameters were obtained from the manufacturer. The finite element method was used to calculate the electric field distribution in the brain. We also included a 'virtual lesion' in the model to simulate the presence of an idealized tumor. The calculated electric field in the brain varied mostly between 0.5 and 2.0 V cm\(^{-1}\) and exceeded 1.0 V cm\(^{-1}\) in 60% of the total brain volume. Regions of local field enhancement occurred near interfaces between tissues with different conductivities wherever the electric field was perpendicular to those interfaces. These increases were strongest near the ventricles but were also present outside the tumor's necrotic core and in some parts of the gray matter-white matter interface. The electric field values predicted in this model brain are in reasonably good agreement with those that have been shown to reduce cancer cell proliferation in vitro. The electric field distribution is highly non-uniform and depends on tissue geometry and dielectric properties. This could explain some of the variability in treatment outcomes. The proposed modeling framework could be used to better understand the physical basis of TTF efficacy through retrospective analysis and to improve TTF treatment planning.