Improved Numerical Modelling of Heat Transfer in Human Tissue Exposed to RF Energy according to blood flow

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My Master's Thesis "Improved Numerical Modelling of Heat Transfer in Human Tissue Exposed to RF Energy" was based on an ongoing in our Laboratory dosimetry project. The aim of the project is to simulate thermal response of human body tissues exposed to RF energy according to improved vascular structure model. It is based on the new algorithm for construction of realistic blood vessel network, new model of blood flow velocity distribution and an approach to solve bio-heat equation in tissue with variable and initially unknown blood temperature distribution. The algorithm generates a discrete 3D representation of both arterial and venous vascular networks and continuous blood velocity vector field for arbitrary enclosed geometries required to represent the complex anatomy of human body and blood flow.

The results will be obtained by applying the developed method to realistic exposure condition. Results will be compared demonstrates relative difference in thermal response of the exposed tissue compared to results obtained by conventional bio-heat equation with constant blood perfusion and temperature. The developed technique may provide more accurate and realistic modelling in thermal dosimetry studies of human body RF exposure.

Due to high cost of experimental measurements, numerical simulations became valuable methods to model and predict temperature rise in the human body related to electromagnetic (EM) exposure at radio frequencies (RF). Bio-heat equation has been used for many years to simulate heat exchange process in tissue. Since the traditional equation has the blood perfusion term defined as a macroscopic tissue dependent constant parameter, it restricts application to more detailed modelling of exposure scenarios, which feature realistic directional blood flow. Some models include spatially constant but temperature dependent blood perfusion that approximate thermal regulation mechanism of human body important to study exposure to high power RF sources. The more advance models include discrete vascular structure and heat exchange mechanism but lack the practical way of its implementation due challenges in generating the vascular network. In order to study blood perfusion effect on heat exchange in tissue a vascular network model is needed and since highly detailed models of real vessel networks are not available, there is a need for computer algorithm that can build realistic artificial vasculature. Efforts to generate artificial vascular networks have been motivated by interest in angiogenesis and study of hypothermia as well as more accurate modelling of RF exposure.

This reaserch introduces a new algorithm that can generate realistic 3D vascular network, and construct blood flow velocities vector field refer thereafter as *capillary*. Proposed approach enables to calculate the effect of capillaries with specific blod flow distribution on heat exchange in tissue. The algorithm also takes into account the irregularities of geometry and complex anatomical features.In computer simulations newly developed Virtual Family (VF) discrete body models of adult male were used.

Future work considers farther development of the algorithm and subsequent integration of new thermal slower with the existing FDTDLab software package.