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Modeling and Measuring the Propagation of Waves Through Tissue

Describing the propagation of electrical signals through tissue is crucial in optimizing the safety of wireless pacemaker recharging technologies. This project is a two-part research endeavor in which (1) a transmission line based model of the propagation of electrical signals through tissue was created, and (2) the validity of this model was tested through experimental means. The model simplifies the travel of a wave through tissue into an alternating current circuit, with each layer of tissue representing a different dielectric in the transmission line. It was coded into a MATLAB program, which uses an inputted frequency to interpolate permittivity values for skin, fat, and muscle layers from data experimentally collected in the "Gabriel Papers." From these permittivities, the program uses transmission line equations to calculate the complex impedance of a tissue apparatus of varying tissue thicknesses. Tissue mimicking phantoms (materials that are electrically similar to tissue) were created and measured in the microwave frequencies to collect experimental complex impedance values for varying thicknesses of tissue phantoms. In comparing theoretical and experimental data, early studies conducted with 1-port S11 data suggest that the transmission line model is statistically ineffective. However, later experiments conducted with more robust broadband antennas show better alignment with complex impedances projected by the model. The model seems to predict the propagation of electrical signals through single layers of tissue, although it does not yet match all multi-layer tissue apparatuses. This model can be used by the medical community to optimize the safety of electrical transmissions through tissue.