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THERMAL CHARACTERIZATION USING FOURIER AND NON-FOURIER CONDUCTION DURING RADIOFREQUENCY ABLATION OF BREAST TUMOR

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ABSTRACT Most of the numerical studies on radiofrequency ablation (RFA) utilize Pennes bioheat transfer equation to predict the temperature distribution and ablation volume post-treatment. Pennes bioheat equation is based on the classical Fourier's law of heat conduction which assumes infinite speed of heat propagation. However, in reality the propagation of thermal disturbance occurs usually at a finite speed with a delay that ranges from 10 to 20 s in biological tissues. The motive of the present study is to investigate the differences between the Fourier and non-Fourier bioheat transfer models during RFA of breast tumor. A heterogeneous three-dimensional two-compartment model of breast has been constructed based on the anatomical details available in the literature. The thermo-electric analysis has been performed using a finite element based COMSOL Multiphysics® software by incorporating the coupled electric field distribution, the bioheat transfer equation and the first-order Arrhenius rate equation. The effect of temperature dependent changes in electrical and thermal conductivities has been incorporated along with a non-linear model of blood perfusion. The numerical simulation results revealed that, Fourier model slightly over-estimates the size of ablation volume produced during RFA of breast tumor as compared to non-Fourier conduction model. The effects of thermal relaxation time on the temperature distribution, input voltage requirement and ablation volume have been studied for both the constant-voltage and temperature-controlled RFA. It has been found that the variation between the temperature distributions obtained from the two approaches is more pronounced initially, and decays with increase in treatment time.

KEYWORDS

Keywords: Radiofrequency Ablation; Breast Cancer; Hyperbolic Bioheat Equation; Pennes Bioheat Transfer; Finite Element Method.