Modeling Electrical and Thermal Conductivities of Biological Tissue in Radiofrequency Ablation

M. Trujillo[1], E. Berjano[1]

[1]Universidad Politécnica de Valencia, Valencia, Spain

Abstract

Radiofrequency ablation (RFA) is a minimally invasive techinique which is used to treat some kinds of cancer [1], [2]. Theoretical models can provide information about the biophysics of RFA quickly and cheaply, but their realism is very important. A very influential factor in this realism is the use of mathematical functions to model the temperature-dependence of tissue thermal (k) and electrical (s) conductivities. The aim of this work is to review the mathematical functions employed to model the temperature dependence of k and s in previous computer modeling studies and to assess how these different functions affect lesion dimension evolution during theoretical computations of RF hepatic ablation with a cooled electrode. To achieve our objective we use a model of RF hepatic ablation in which both conductivities are modeled with different mathematical functions and compare the lesion sizes obtained in every case. We employed the thermal damage contour D63 to compute the lesion dimension contour, which corresponds to $\Omega= 1$, Ω being local thermal damage assessed by the Arrhenius damage model. We solve the problem numerically using COMSOL Multiphysics software. The resulting model is a multiphysics model with three types of problems: electrical, thermal and a PDE, General Form problem to introduce the Arrhenius damage model. For the energy delivery we use a pulsed protocol which depends on the impedance value for each time. To introduce this protocol we use the interaction between COMSOL and Matlab. Results are very similar in all the cases and show that differences considered in terms of lesion size are smaller than 3.5%. The results suggest that the different functions to model the temperature dependence of k and s do not significantly affect the computed lesion diameter.

Reference

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