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Investigation of a porous model applying on the thermal response prediction of a spherical biological tissue during hyperthermia therapy

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This study utilizes a porous model to predict the temperature response of a spherical tissue with a heating in its central region. The porous model considers the tissue with its blood vessel distribution as a porous medium and employs the convection term in the energy conservation equations for both tissue and blood. This study collects the relative data of blood vessel sizes (8~140 μm) and velocities (0.7~34 mm/s) from previous literatures, and then estimates the parameter values in the porous model. By using a numerical method, the temperatures response of tissues with different vessel diameters, blood velocities, and porosities were calculated. This study also applies the well-known Pennes model to simulate the temperature response of the tissue with same conditions and corresponding perfusion rate, which is set as the mass flow rate of the blood. Through the comparison with each other, the numerical results calculated by the porous model coincide with those calculated by Pennes model when the blood vessel diameter is small (8μm). When the vessel diameter increases, the convection effect of blood becomes apparent due to its faster velocity and affects the temperature distribution of the tissue moving toward the downstream, which one is a reasonable phenomenon and different to the result of Pennes model. The preliminary results indicate that the Pennes model is suitable for analyzing a tissue with a distribution of blood vessel less than 100μm. Moreover, the temperature responses in the center of the tissue predicted by the two models have obvious difference in some cases with larger diameter blood vessels. Authors speculate that the difference between the porous model and Pennes model in these cases should be caused by the selection of perfusion rate value in Pennes model. Once the perfusion rate calculated is replace by an equivalent perfusion rate, the results predicted by both model will be more consistent.

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