The Modeling of Radiofrequency Cardiac Ablation Treatments :Porous Media Theory (Effects of Natural Convection and Poromechanical Deformation)

Radiofrequency Cardiac Ablation (RFCA) is a non-surgical procedure to destroy abnormal pathways causing cardiac arrhythmias within the cardiac chamber. RF energy from electrodes contacting the cardiac tissue generates heat, raising tissue temperature and ablating it. Success of the procedure, as in avoiding complications like steam pops, requires its comprehensive mechanistic understanding. Using a 3-D porous media-based model of the cardiac tissue and surrounding chamber blood, with coupled fluid flow, heat transfer (including evaporation and thermally driven natural convection), poromechanical deformation, and resistive heating, provided a more complete picture of the thermal ablation process. Circulation of blood due to buoyancy-driven natural convection reduces the non-uniformity of temperatures, by reducing temperatures initially in the target region but increasing them in the later stages, compared to when natural convection effects are not included. Poromechanical expansion of the tissue from temperature rise reduces blood velocity, increasing tissue temperature. Thus, natural convection and poromechanical deformation affect possible steam pop occurrence differently over the time for the procedure. The more complete picture of the RFCA procedure provided here by the detailed physics-based model can benefit with increased accuracy and thus reduced re-ablation (thus higher success rates), and reduced costs for catheter design and development.

Keywords: radiofrequency cardiac ablation; modeling and simulation; porous media; steam pop; natural convection; poromechanical deformation