Computational Modeling of Electrode with Saline Irrigation for Radiofrequency Cardiac Ablation

J. H. Moon[1], J. W. Ahn[1], Y. J. Kim[1], S. A. Lee[1], H. C. Jung[1], S. H. Lee[1]

[1]Osong medical innovation foundation, medical device development center, Cheongju-Si, South Korea

Abstract

Radiofrequency catheter ablation is the interventional therapy that be employed to eliminate cardiac tissue caused by arrhythmias. During radiofrequency catheter ablation, the formation of thrombus can occur at electrode tip if the temperature of interface between electrode tip and cardiac tissue reaches around 80℃, lead to the adherence of blood and make difficult to eliminate cardiac tissue. To prevent this phenomenon, the saline irrigable electrodes have been developed and can inject saline into blood-tissue interface through holes around electrode tip. There are numerous computational modeling about radiofrequency catheter ablation. The previous model did not solve the fluid problem associated with the blood circulation in cardiac chamber and the saline irrigation flow, and substituted the convective heat transfer for the heat flux condition at the tissue-blood interface. The saline irrigation flow was substituted by fixing the temperature of electrode tip and simplified by the zone of the electrode surface corresponded the irrigation holes location without modeling individually the irrigation holes to reduce computational cost. We investigate the computational modeling electrode with saline irrigation including the flow problem about the blood circulation and the saline irrigation flow.

The problem we wish to solve is the temperature distribution of cardiac tissue, electrode and blood when the saline is injected through the electrode including 6 irrigation holes. The model is based on coupled electric-thermal-flow problems. The governing equations are Energy equation, Navier-Stokes equation and Maxwell equation. To solve the coupled problems, we use AC/DC Module, Heat Transfer Module, and CFD Module in COMSOL Multiphysics® software. In the properties of the materials, the electrical and thermal conductivity of cardiac tissue are temperature-dependent function. We consider a temperature-control ablation on the electrode tip. To control the temperature of the electrode tip, the model is implemented standard proportional-integral(PI) control system by setting the probe of temperature at the electrode tip. In the flow problem, the inlet velocity boundary condition is applied on the left surface to impose a blood flow 0.1 m/s. In the thermal boundary conditions, the temperature of the outer surface is constant 37℃. And the temperature of the saline injected through the electrode and catheter body is constant 20℃ at the entrance of catheter body. To characterize the thermal lesion with the 50℃ isotherm contour, we choose two parameters: the flow rate of the saline irrigation and the set temperature of the electrode tip.

The results of the models show that the dimensions of the thermal lesion are increased if the flow rate of the saline irrigation and the set temperature are increased. However, the

temperature of cardiac tissue over 80℃ is observed and result in char and thrombus. To prevent the temperature of cardiac tissue from exceeding 80℃, the set temperature of the electrode tip must be set differently according to the flow rate of the saline irrigation. We need to study more the model by varying the contact angle between the electrode and the cardiac tissue.

Figures used in the abstract

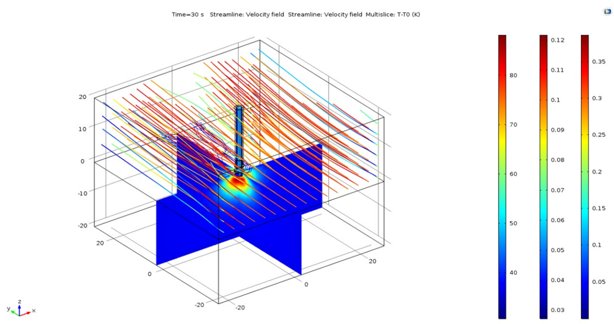

Figure 1: The temperature distribution and streamline of the model.