COMPUTATIONAL MODELING TO STUDY THE TREATMENT OF CARDIAC ARRHYTHMIAS USING RADIOFREQUENCY ABLATION

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Abstract

Introduction: Radiofrequency ablation (RF) is a minimally invasive procedure that consists of creating lines of conduction block aimed to destroy thermally ventricular tissue causing cardiac arrhythmia. Previous studies have proposed using bipolar radiofrequency ablation (RFA) across two catheters placed on opposing surfaces of the ventricular wall as a means of creating transmural lesions [1,2].

Methods: 2D and 3D models were built and solved numerically using the Finite Element Method (FEM) with COMSOL Multiphysics software (COMSOL, Burlington MA, USA). With these models, it was possible to study the temperature distribution and lesion geometry during RFA of the ventricular wall and to compare the potential of two ways of applying electrical currents: bipolar mode (BM), the electrical currents flow between both catheters, vs. sequential unipolar mode (SUM), the currents flow between one catheter (active) and dispersive electrode. Moreover, we investigated the effect of other factors such as the ventricular wall thicknesses, the catheter misalignment and the positioning of the electrodes on the ventricular wall: the interventricular septum (IVS), the wall between both ventricles, or ventricular free wall (VFW), the wall between one ventricle and epicardial space.

Results: BM across the IVS created transmural and symmetrical lesions for wall thicknesses (5 - 15 mm), but with geometry that varied according to tissue thickness. Additionally, the lesions with BM became longer as the misalignment between electrodes increased. In contrast, SUM did not create transmural lesions when tissue thickness was greater than or equal to 12.5 mm. With respect to VFW ablation, BM created transmural lesions provided that air has not been accidentally introduced into the epicardial space. In this case, SUM was able to create transmural lesions only when the thickness of the ventricular free wall was equal to or less than 7.5 mm.

Conclusions: The computational results suggest that BM is in general more effective than SUM in achieving transmurality through the ventricular wall, i.e. to create lesions across the tissue thickness. These results could improve the safety and performance of these procedures.

Reference

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2. Koichi Nagashima, Ichiro Watanabe et al., Lesion formation by ventricular septal ablation with irrigated electrodes: comparison of bipolar and sequential unipolar ablation. Circulation Journal, 75, 565–570 (2011).