MR-Based, Patient-Specific Computational Simulation to Recapitulate Scar-Related Ventricular Tachycardia

Hiroshi Ashikaga¹, Hermenegild Arevalo², Fijoy Vadakkumpadan², Robert Blake², Ronald Berger¹, Hugh Calkins¹, Natalia Trayanova², Henry Halperin¹

¹Division of Cardiology, Johns Hopkins University School of Medicine, USA, ²Institute for Computational Medicine, Johns Hopkins University

In scar-related ventricular tachycardia (VT), a part of heterogeneous zone (HZ), a highly complex mixture of scar and normal-appearing tissue, may be the region of slow conduction that serves as the substrate for reentry. Currently, we use invasive catheter mapping to “search and destroy” this slowly conducting tissue. Our aim is to investigate the role of the MRI-defined HZ as the VT ablation target by utilizing MRI-based computational simulations. In 13 patients with scar-related VT (age 65±9years, EF 42±16%) referred for VT ablation, pre-ablation MRI with late gadolinium enhancement (LGE) was performed. Scar and HZ were defined by LGE and were integrated into computational simulation. The scar was modeled as an insulator, and HZ as the slowly conducting tissue. Myofiber orientation was estimated from the ventricular geometry. Simulation results were validated against electrophysiology study, mapping, and actual 12-lead ECG data. Simulated surface 12-lead ECG of the induced simulated VT matched well with the actual surface ECG of clinical VT. Ablation lesions were simulated by creating areas of insulation. In all cases, the successful ablation sites coincided with the optimal ablation targets predicted by simulation. We conclude that, using pre-ablation MRI, scar-related VT can be reproduced in computer simulation and successful ablation sites can be accurately determined.

Keywords: computer simulation, cardiac MRI, ventricular tachycardia