Noninvasive Electrocardiographic Imaging of Scar-related Ventricular Tachycardia: Association with Magnetic Resonance Scar Imaging

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Background: Ventricular tachycardia (VT) due to reentry formed by myocardial infarction scar is a major cause for sudden cardiac death. Catheter ablation can control frequent VT episodes once a proper ablation target is identified through electrical mapping. However, invasive approaches to map VT circuits and substrates are limited by the sampling density. The aim of this study is to investigate the performance of electrocardiographic imaging (ECGi) – a noninvasive approach to electrical mapping -- to map scar substrates and VT circuits in relation to high-resolution DCE-MRI scar imaging obtained on animal models.

Methods: Four post-infarction swine models were created. On each animal, DCE-MRI was obtained with a resolution =0.48 mm, from which 3D anatomical architecture of the scar core and border zone was delineated. At the same time, ECGi was performed using 120-lead ECG during sinus rhythm and induced VT, along with MRI-derived heart-torso models. Features were extracted from ECGi computed electrograms (CEGM) during sinus rhythm and associated to DCE-MRI characterization of tissue types (scar core, gray zone, and healthy myocardium). Activation time maps were extracted from CEGM obtained during induced VT, and qualitatively analyzed with respect to the DCE-MRI scar.

Results:
In sinus-rhythm, ECGi computed electrograms (CEGM) showed an average maximum amplitude of 693.99±727.61 in DCE-MRI healthy myocardium, versus 399.55±419.18 in DCE-MRI scar tissue (p=0.012, paired-ttest). Within the scar, CEGM showed an average maximum amplitude of 354.27±451.11 in DCE-MRI scar core, versus 424.48±310.03 in DCE-MRI gray zone (p=0.042, paired-ttest). In VT, ECGi-reconstructed activation time maps consistently revealed re-entrant circuits exiting within or near the region of DCE-MRI scar.

Conclusion:
ECGi reconstructions of sinus-rhythm scar substrates and induced VT circuits agree well with scar data obtained from DCE-MRI. Noninvasive ECGi of VT and scar substrates may serve as a useful conjunct to invasive catheter mapping to improve the identification of ablation targets.

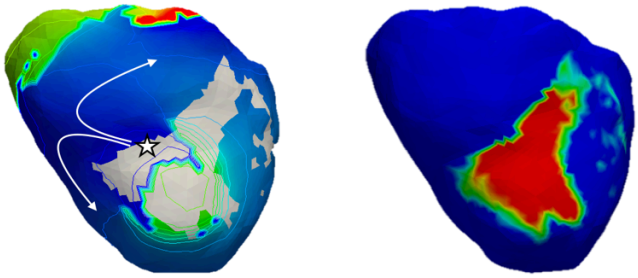

Figure 1 Left: Activation time map of VT circuits extracted from ECGI. This map illustrates that the activation starts (white star) at the border of scar (gray region) and shows how the activation develops over the epicardium around the scar (white arrows). Right: Myocardial scar (red) delineated from DCE-MRI