Noninvasive Three-dimensional Cardiac Activation Imaging of Ventricular Arrhythmias in the Rabbit

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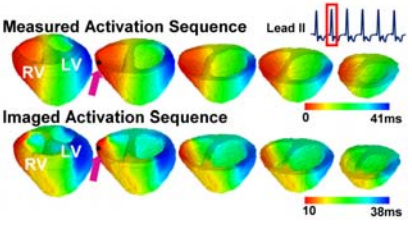
Imaging myocardial activation is important for cardiovascular research and clinical medicine. The present study aims to rigorously assess the imaging performance of a physical-model based 3-dimensional cardiac electrical imaging (3-DCEI) approach with the aid of simultaneous 3-D intra-cardiac mapping from up to 200 intramural sites during ventricular arrhythmias induced by norepinephrine (NE) in the rabbit heart.

The physical-model based 3-DCEI approach is developed by modeling 3-D cardiac electrical activities using equivalent current densities (ECDs) and by mathematically solving a spatial-temporal linear inverse problem from body surface potential maps (BSPMs). In this study, BSPMs were obtained simultaneously with intramural bipolar recordings using plunge-needle electrodes in a closed-chest condition in four healthy rabbits. Ventricular arrhythmias including premature ventricular complexes (PVCs) and accelerated idioventricular rhythms (AIVRs) were induced by intravenous NE infusion. Computer tomography (CT) images were obtained after the mapping study for realistic heart-torso geometry models.

The non-invasively imaged activation sequence correlated well with the directly measured counterparts, with an averaged correlation coefficient of 0.73±0.03, and a relative error of 0.31±0.03 over 24 PVCs and 6 runs of AIVRs. The arrhythmia beats initiated by a focal (nonreentrant) mechanism as evident by 3-DCEI. The initiation sites covered both LV and RV, including outflow, apex, lateral, anterior and posterior walls. Sites of initial activation were well localized to within ~5mm for the ectopic beats.



Example of the comparison between the measured and the imaged activation sequence of a ventricular arrhythmia beat in the rabbit heart.

The present result suggests that the 3-DCEI approach can non-invasively reconstruct 3-D ventricular global activation sequence and localize the origin of activation during focal ventricular arrhythmias. It also implies the potential application of 3-DCEI as a clinically useful tool to aid in localizing the origins of ventricular arrhythmias and understanding the mechanism of these arrhythmias.