Comparison of High Resolution LGE and High Resolution Electro-Anatomical Mapping for Imaging of the Ventricular Arrhythmia Substrate in a Swine Model of Ventricular Tachycardia

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Target Audience

Scientists and clinicians who are interested animal models of ventricular tachycardia.

Purpose/Introduction

Sudden cardiac death (SCD) if often induced by ventricular tachycardia and fibrillation (VT/VF). ICD therapy is the first line therapy for the prevention of SCD. Combination of ICD therapy with catheter based VT ablation has been shown to reduce the incidence of ICD therapy in patient with history of myocardial infarction[1]. However, the recurrence rate of VT/VF after VT ablation is about ~50% in these patients[1]. It is currently advocated that techniques for better identification of the VT substrate combined with better control/monitoring of the delivered energy could improve the outcome of this procedure. The VT substrate consists of reentry circuits near or within a chronic scar. Invasive catheter mapping using electro-anatomical system (EAM) is the clinical standard for identification of reentry circuits. However, current EAM systems have several limitations including low spatial resolution, lengthy procedural time, sensitive to contact contact/orientation, etc. Late gadolinium enhancement (LGE) CMR has the potential for non-invasive identification of reentry circuits, but LGE sequences suffer from low spatial resolution and partial voluming[2]. In this study, we sought to utilize a high-resolution 3D LGE sequence with 1 mm^3 isotropic spatial resolution to image a surrogate of the VT substrate in swine model of VT and to compare these findings with high resolution EAM.

Materials and Methods

Imaging experiments: A swine model of VT was induced in 6 Yorkshire swine using a 180 minutes balloon occlusion of the mid left anterior artery. In-vivo CMR was then performed at 52±13 days after infarction using a 1.5 T Philips scanner. Each animal received an injection of 0.2 mmol/kg of gadobenate dimeglumine. High resolution LGE was performed using a free breathing navigator-gated inversion recovery gradient echo (GRE) sequence (TR/TE/α=6.5/3.0ms/25˚, FOV=270×270×112 mm^3, voxel size=1×1×1 mm^3, compressed sensing factor=4). These data were reconstructed using a B_1-weighted reconstruction based on LOST[3].

An electrophysiology study was subsequently performed using a novel proprietary high-resolution 64 electrode basket catheter (Rhythmia Medical) with programmed stimulation to assess for VT inducibility. This system enabled full LV mapping with ~7000 sampling points within approximately 15 minutes.

Data Analysis: In-vivo LGE data were analyzed offline[4]. Endocardial and epicardial contours were manually delineated. The transmural intensity was computed for each endocardial vertex and was averaged over the inner 1 mm layer of the myocardium. These values were finally normalized (where '0' corresponded to 3 standard deviations above the mean signal intensity of normal myocardium and '1' corresponded to 60% of the maximum signal intensity of the scar area) and projected on the endocardial shell.

High resolution EAM data were inspected by a second experienced operator in order to remove points with assumed incorrect catheter contact. Conventional bipolar voltage threshold were used for visualization (core scar: voltage ≤ 0.5 mV; border zone: 0.5 mV ≤ voltage ≤ 1.5mV).

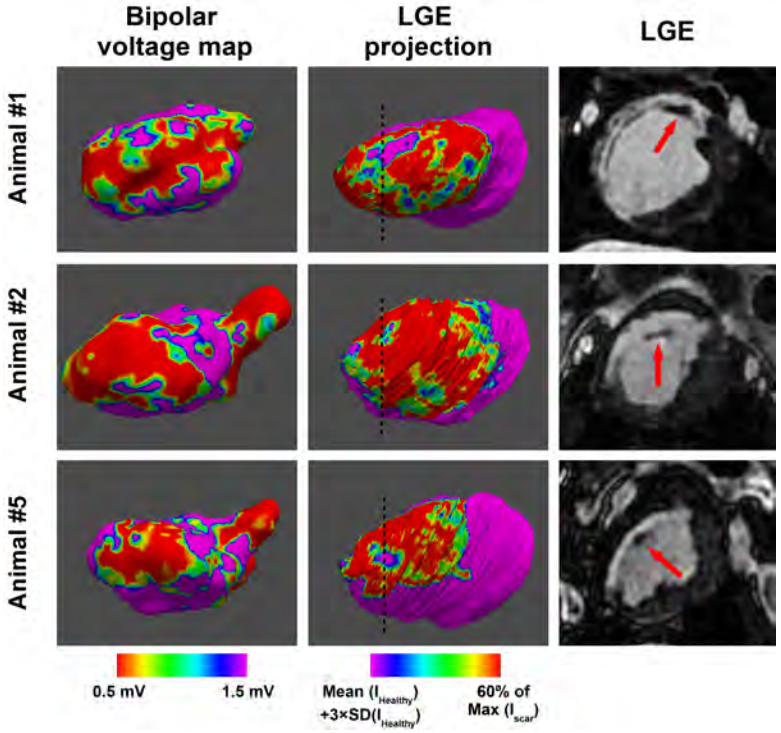

Figure 1. *Bipolar voltage maps and in-vivo LGE obtained in three different swine. "LGE projection" (middle column) is the normalized average transmural intensity over the inner 1 millimeter layer of the myocardium. Viable myocardium can be observed within the scar territory using high resolution LGE data (red arrows). The core scar area (bipolar voltages < 0.5 mV and LGE normalized projection > 60% of Max(I_{scar})) is also matching between both datasets.*

Results

Sustained reentrant VT was induced in all animals during the EP experiment. Figure 1 shows high resolution EAM maps and high resolution LGE data obtained in 3 swine. The overall scar area was located in the septal area of the three swine in both bipolar voltage maps and LGE data. Islands of viable myocardium can be visualized within the scar territory of all animals (red arrows). Visual matching was observed between the inner 1 millimetre layer of the myocardium in LGE data high resolution bipolar voltage maps.

Conclusions

High resolution LGE with 1 mm^3 isotropic resolution enables imaging of a surrogate of the VT substrate as defined by high-resolution EAM. Further studies are warranted to evaluate the relationship between novel LGE biomarkers and the VT substrate defined by higher solution EAM.

Acknowledgements

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References

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