Effect of Scar Interpolation Methods on Simulated Ventricular Tachycardia in Infarcted Heart Models

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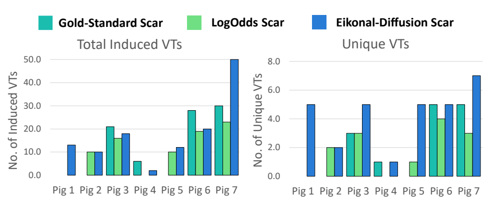
Background: Computational models have demonstrated potential for ablation target identification of myocardial infarction related ventricular tachycardia (VT) and arrhythmic risk stratification. However, patient-specific models are typically derived from low interslice resolution cardiac MRI (CMR), which may impact the accuracy of complex scar morphologies and conducting isthmuses which are known critical VT substrates.

Objective: To quantify the effect of scar interpolation methods during CMR-based model construction on VT inducibility and identify optimal approaches for accurate scar reconstruction.

Methods: Computational models of the left ventricle (LV) and scar were generated using late-gadolinium enhanced (LGE) CMR with 1mm isotropic resolution (gold-standard) for a porcine cohort of 7 infarcted hearts. Scar tissue was downsampled to a short-axis inter-slice resolution of 10mm and two further models with interpolated scar were generated using: (i) statistical shape reconstruction based on the LogOdds function and (ii) anisotropic Eikonal-diffusion of scar along apex-base (long-axis) orientations, with optimum parameters identified from sensitivity analysis. Subsequently, the Virtual Induction and Treatment of Arrhythmias (VITA) framework was applied to the virtual cohort to probe the viability of scar substrates in sustaining re-entrant circuits and the number of induced VTs compared.

Results: LogOdds and Eikonal-diffusion interpolation achieved a similar anatomical accuracy to the gold-standard scar, with a mean Dice coefficient of 70%±4.6% and 72%±7.0%, respectively. However, application of VITA to Eikonal-diffusion models induced several unique VTs in 3 out of 7 pigs, despite no VTs induced in the gold-standard. Furthermore, LogOdds scar models induced a comparable number of unique VTs to the gold-standard, whereas Eikonal-diffusion models induced a consistently greater number of unique VTs.

Conclusion: While both interpolation approaches achieved a similar anatomical accuracy, the LogOdds method was functionally superior, affirming the critical role of the method used to include precise anatomical detail in functionally accurate models to determine VT inducibility.



VITA simulation results.