Abstract: P572

Pre-clinical evaluation of a real-time MRI-guided electrophysiology system for ventricular tachycardia

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Background
Potential advantages of real-time magnetic resonance imaging-guided electrophysiology (MR-EP) include contemporaneous 3D substrate assessment at the time of intervention, improved procedural guidance and ablation lesion assessment using active tracking and MR-thermometry techniques respectively. Electrophysiology studies within a MRI scanner however is challenging as significant electromagnetic interference can distort signals and corrupt electrogram fidelity. Combined MR-EP techniques could offer synergistic benefits for evaluation and ablation of ventricular tachycardia (VT) substrate.

Purpose
We evaluated the ability of a novel real-time MR-EP system to perform endocardial voltage mapping and limited pace mapping in a porcine ischaemia-reperfusion model. Sites of low voltage and slow conduction identified using the system were registered and compared to regions of late gadolinium enhancement (LGE) on MRI.

Methods
A closed-chest balloon occlusion model was used to generate infarcts in 5 male domestic pigs. A MR-compatible irrigated ablation catheter with a single 3.5mm gold tip and ring bipolar electrode, paired with a dedicated prototype image guidance platform, was used to acquire activation and voltage maps in the swine left ventricle (2 healthy, 5 post infarction). Limited pace mapping was performed in sinus rhythm to derive the interval from the stimulus artefact to the onset of the peak R wave on the surface QRS (S-QRS) as the most reproducible deflection. MRI-identified scar was taken as the ‘gold standard’ for structural substrate assessment. Sensitivity and specificity of voltage and S-QRS measurements generated from the MR-EP system to predict location of scar regions were assessed and used to derive receiver operator characteristic (ROC) curves.

Results
A total of 445 electrograms were recorded in sinus rhythm (range: 30-186) using the MR-EP system including 138 electrograms from MR-derived LGE regions. Pacing captured at 103 sites; 56 (54.4%) sites had S-QRS delay <40ms, 47 (45.6%) sites had a delay of >40ms whilst 15 (14.5%) had a delay >80ms. Of sites with delay, 45 were in regions of MR-derived LGE and 58 were in regions of normal myocardium.

Using conventional (0.5mV-1.5mV) bipolar voltage thresholds, the sensitivity and specificity of voltage mapping using the MR-EP system to identify MR-derived LGE was 57% and 96% respectively. Voltage mapping had a better predictive ability in detecting infarct scar compared to S-QRS measurements using this system (area under curve: 0.907 vs 0.840).
Conclusion
Low voltage zones and regions of prolonged S-QRS determined using a real-time MR-EP system are predictive of LGE areas identified on MRI.