

## MR-guided evaluation of post-infarction ventricular tachycardia

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### Introduction

Sudden cardiac death (SCD) accounts for approximately 50% of cardiovascular mortality, resulting in more than 400,000 deaths annually in the United States. Many cases of SCD result from reentry ventricular tachycardia (VT) after myocardial infarction (MI). Although catheter-based radiofrequency ablation of myocardial scar can prevent fatal arrhythmia, the procedure can be technically challenging and incomplete, because it is guided only by electrophysiological parameters within the ventricles. Several lines of evidence suggest that there is a correlation between the scar geometry and the reentry circuit. Therefore, detailed scar geometry may help predict the foci of reentry circuits. We set out to develop a registration technique to merge geometrical data of the myocardial scar with the electrophysiological information.

### Methods

Myocardial infarction was created in mongrel dogs weighing 25-30kg by ligation of the left anterior descending coronary artery near its base. Three to eight weeks following MI, the animal underwent a median sternotomy under general anesthesia. The heart was placed in a pericardial cradle, and a multi-electrode epicardial sock consisting of a nylon mesh fitted with 247 silver electrodes attached in an ordered fashion was placed over the ventricular epicardium. The sock was placed in a consistent and predetermined orientation for all experiments and secured with several sutures. An MR-compatible pressure micromanometer catheter (Millar, SPC-350, 5Fr) was advanced under fluoroscopic guidance to the left ventricular (LV) cavity through a 6Fr arterial introducer placed in the right carotid artery. A ground reference electrode was sewn onto the fat pad at the aortic root. Electrical signals were recorded using a PC-based data acquisition system with a minimum sampling rate of 1 kHz. The animal underwent the standard clinical programmed stimulation protocol from multiple sites on the sock array to induce ventricular tachycardia. After tachycardia was recorded, gadopentetate dimeglumine (Gd-DTPA, 0.20 mmol/kg iv) was administered. Twenty minutes later, the animals were euthanized and the heart excised. The heart was filled with vinyl polysiloxane to maintain the end-diastolic shape, and the locations of electrodes were digitized (Microscribe 3DLX, Immersion Corporation, San Jose, CA). Ten to fifteen 10mm x 1mm glass tubes (18 $\mu$ L) filled with Gd-DTPA (5mM) were placed in the myocardium, and digitized. These tubes were used as markers for registering MR and electrical data.

The sock electrodes were removed from the heart, and the heart was scanned in a 1.5T MR scanner (Siemens Sonata) using an extremities coil with a 3D GRE sequence to visualize the infarction *ex vivo* (1) and to locate the glass tube markers (BW  $\pm$ 130 Hz/pixel, FA 20°, TE/TR 4.02/9.7 ms, FOV 100 x 100 mm, image matrix 256 x 256, spatial resolution 0.39 x 0.39 x 0.39 mm). Three-dimensional (3-D) coordinates of the ventricular myocardium and myocardial infarction were extracted from the MR images using a signal intensity threshold to visualize a volumetric image of the myocardial infarction in the ventricles (Figure X). The locations of the glass tube markers were determined from the MR images (Figure X), and the electrodes were registered to the MR images. The electrical activation time, or local depolarization time, at each electrode was defined as the peak negative dV/dt within the QRS complex. The time reference for the local depolarization times was the earliest ventricular depolarization time in each heart. The isochrone map of the electrical activation time was visualized on the spherical harmonic mesh (2) of the ventricular epicardial surface extracted from the MR images.

### Results

Figure 1 shows the raw MR images of the heart. The area of high signal intensities (arrow A) represents myocardial infarction (MI). One of the glass tube registration markers is indicated by arrow B. Figure 2 shows 3-D volumetric reconstruction of the MR image that shows MI (red) in the normal myocardium (blue). Figure 3 shows registration of the MR images with the isochrone map showing reentry ventricular tachycardia. The local depolarization or activation time is color-coded (in msec), and the white arrows show a classic figure-of-eight type of reentry circuit.

### Conclusion

We demonstrate that this MR-guided visualization technique can help localize the reentry VT circuit with reference to the 3-D scar geometry. Further study is needed to develop a clinically applicable registration scheme that can guide a catheter-based ablation therapy.

### Acknowledgement

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### References

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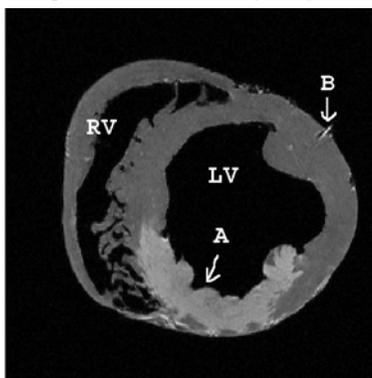


Figure 1: Raw MR image  
RV, right ventricle; LV, left ventricle

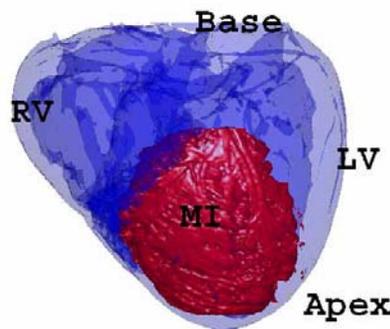


Figure 2: 3-D volumetric reconstruction  
MI, myocardial infarction

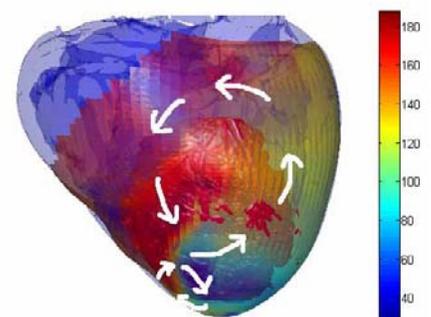


Figure 3: Registration with electrical data  
White arrows represent a reentry VT circuit