Accuracy of detecting gaps in atrial RF ablation using LGE MRI

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Introduction: Radiofrequency (RF) ablation of the left atrium (LA) and pulmonary vein ostia has become a clinically acceptable therapy for atrial fibrillation (AF) [1,2]. One of the main hurdles of this interventional procedure is the inability to adequately evaluate tissue injury caused by RF ablation during the procedure itself, resulting in recurrence of AF and the need for repeat procedures [3]. With the advent of MRI sequences to visualize post ablation scar and assess treatment outcome [4,5], MRI offers a promising method to assess these RF ablations. Real-time (RT) MRI [6] is becoming a useful tool for interventional applications and has been tested for atrial ablation as well [7,8]. Previously, it has been shown that targeted ablation of lesion gaps may be performed under RT-MRI guidance to improve procedure outcome [9]. However, the accuracy of the imaging strategy used to identify lesion gap targets was not validated and verified. **In this work, we strive to determine the accuracy of the Late Gadolinium Enhancement (LGE) MRI technique used to determine the gaps between lesions to optimize and improve the RT-MRI guided targeted RF ablation of lesion gaps.**

Methods: Two experiments to create RF lesions in the right atrium (RA) and right ventricle (RV) of adult minipigs (weight 26 and 32 kg) were performed according to protocols approved by the local IACUC. Catheter access was by means of a 12F introducer sheath placed in the right femoral vein to enable the introduction of a novel, 8.5F, 3-Tesla MR-compatible, irrigated, temperature sensing, mapping and ablation catheter (MRI Interventions Inc, Irvine, CA). The catheter, equipped with tracking coils for navigation/MR guidance, was connected to the RF generator using MR compatible interface circuits (MRI Interventions Inc, Irvine, CA), custom built for 3-Tesla magnetic field. All MR imaging was performed using the body and spine array Tim coils at 3-Tesla using a Siemens MAGNETOM Verio scanner (Siemens Healthcare, Erlangen, Germany) with RT-MRI guidance provided using custom prototypes based on the IRTTT real time pulse sequence and the Interactive Front End (IFE) navigation software (Siemens Corporate Research, Princeton, NJ).

The MRI study began with the localizers, followed by a contrast-enhanced, 3D MR angiography (contrast dose of 0.15 mmol/kg, injection rate of 0.15 ml per second, Multihance, Bracco Diagnostic Inc., Princeton, NJ). The MRA image was then segmented to create a shell of the aorta, RA and RV respectively and imported to the IFE MRI navigation platform (Siemens Corporate Research, Princeton, NJ). The electro-physiologist then performed ablations in the MRI suite with a typical wattage of 30W, for 30-60 seconds using the Stockert RF ablation unit (Biosense Webster, DiamondBar, CA). Ablations were performed, as they would be in the conventional EP-suite. Contrast was then injected again at the end of ablations to perform serial LGE imaging [10], to assess acute injury. The parameters for the different scans were as follows: RT-MRI: 2D GRE sequence with resolution=1.8x2.4x4 mm, TR/TE=3.5/1.5 ms, flip angle=12^o, acceleration R=2, 4 frames per second; MRA: respiratory navigated, ECG gated, 3D GRE with resolution=1.25x1.25x2.5 mm, TR/TE=2.8/1.3 ms, flip angle=20^o, R=2; LGE: respiratory navigated, ECG gated, inversion recovery prepared GRE with resolution=1.25x1.25x2.5 mm, (or higher resolution = 1x1x1.5 as shown in Figure 1(b & d) TR/TE=2.9/1.4 ms, flip angle=14^o. At the end of the study, the animal was euthanized and the heart extracted for macroscopic examination. Measurements between lesion gaps were made on the serial LGE MR images (Osirix Imaging Software) as well as on the ex-vivo heart as shown in Figure 1.

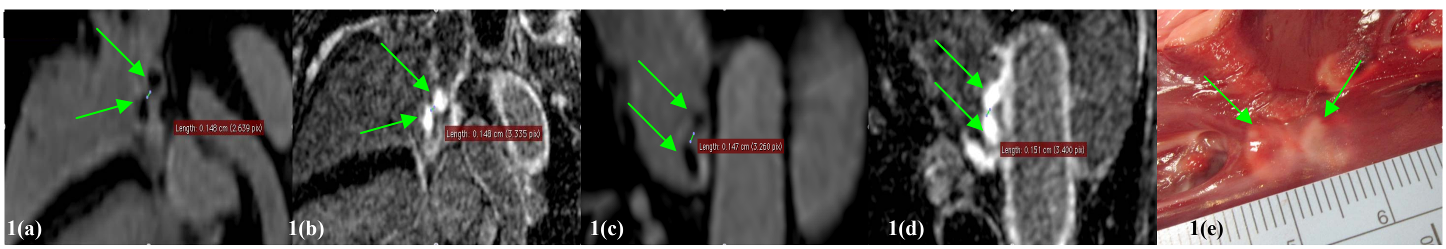

Figure 1. (a)-(e) Measurements of gap between ablation lesions in **(a),(c)** – Early LGE MRI (<7 mins post contrast injection); **(b),(d)** – Late LGE MRI (>75 mins post contrast injection); **(e)** Ex-vivo atrial tissue

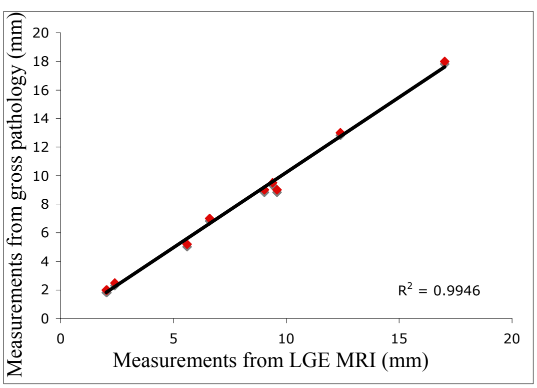

Figure 2. Correlation between lesion gap measurements made in LGE-MR images and ex-vivo measurements.

Results: Figure 2 shows the correlation between the measurements made on LGE-MRI and the ex-vivo measurement. In both the studies, the gaps between lesions in the RA and RV (range 1.5mm – 13mm) were detected by LGE-MRI and correlated very well with ex-vivo measurements.

Conclusion/Discussion: In this work, we have shown that LGE-MRI provides a robust means of detecting small gaps between ablation lesions, thus providing a confirmation of effectiveness that is not available using conventional approaches like endocardial voltage mapping. The results show that the lesion gaps measured using LGE-MRI strongly correlate (99.5%) with the actual measurements made in the ex-vivo heart. RT-MRI and associated devices and software provide a viable means to carry out additional targeted ablations based on this MRI based evaluation technique.

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