

Visualizing Acute RF Ablation Lesions in the Heart using Non-Contrast MRI at 3T

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Introduction: Radio frequency (RF) ablation of the left atrium (LA) and pulmonary vein (PV) ostia has become a clinically acceptable therapy for atrial fibrillation (AF) [1,2]. Currently, this interventional procedure is performed under x-ray fluoroscopy and the associated radiation burden provides strong motivation for alternative imaging approaches. With the advent of improved magnetic resonance imaging (MRI) sequences to visualize post ablation scar and assess treatment outcome [3,4], MRI offers a promising alternative to guide and assess these RF ablations. Previous studies [5] have shown the use of MRI compatible RF ablation catheters and performed ablation under MRI. They used non-contrast and delayed enhancement imaging techniques to assess and characterize lesions in the ventricle. In [6], a non-contrast enhanced MRI technique to characterize sub-acute (30 minutes or longer) RF ablation lesions on a canine model was described. They performed RF ablation on the epicardial surface of the ventricle using standard clinical catheters and RF generator outside the MRI scanner, and assessed the lesions using non-contrast MRI.

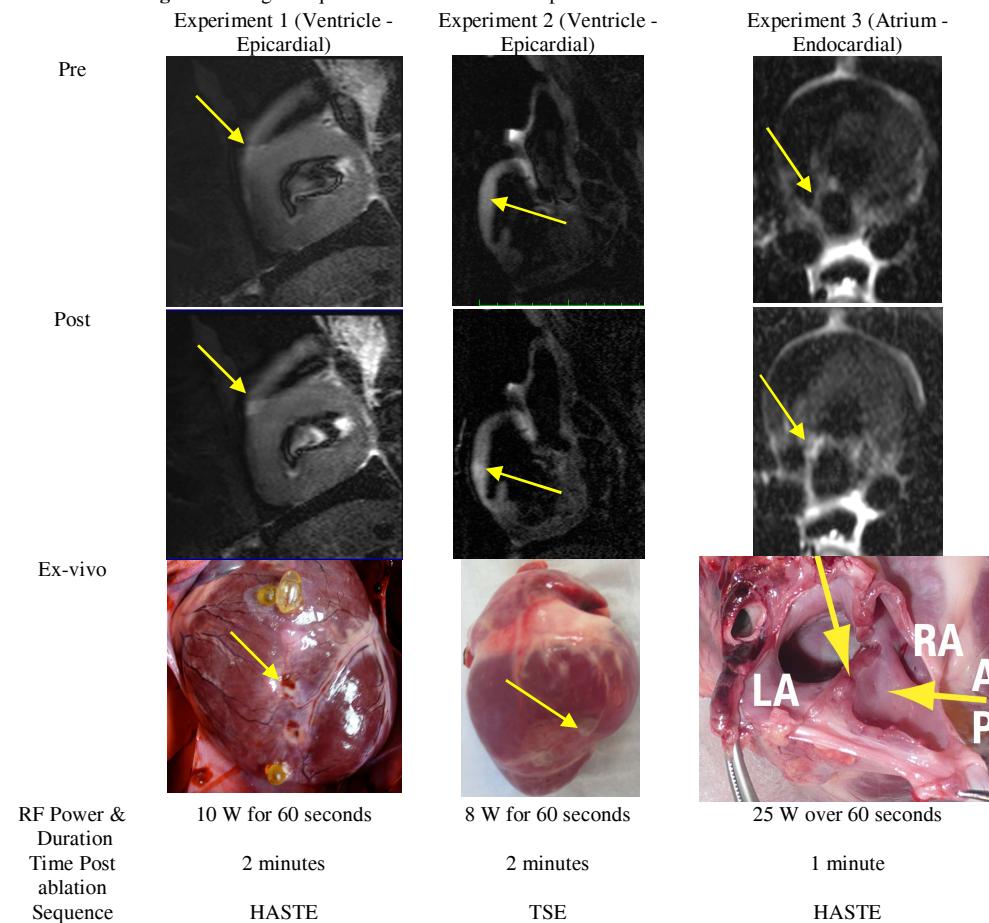
In this work, which is a part of a study to establish MR as viable approach to guide RF ablation, we investigated: 1) How rapidly after application of RF energy can a lesion be visualized using MRI? 2) Is an MR contrast agent necessary to visualize acute lesion? 3) Can the results observed in the ventricle be reproduced in the atrium (the main target region for treatment of AF using RF ablation)?

Methods: Three canine experiments were performed in which two of the dogs underwent midline thoracotomy to access the epicardial surfaces of the heart, with an open pericardium. The third dog was treated subcutaneously with a 10F introducer sheath placed in the right femoral vein for an MR compatible catheter to introduce into the right atrium. ECG and depth of anesthesia were monitored throughout the experiments, and all animal protocols were reviewed and approved by the local IACUC. All ablations were performed using the Stockert RF generator (Biosense Webster, CA) with MR compatible interface circuits, custom built for 3 Tesla magnetic fields. All imaging was performed using custom made canine cardiac coils on a 3T Siemens TIM Trio scanner (Siemens Healthcare, Erlangen, Germany).

The two canine experiments performed with the open-chest protocol made use of vitamin E pills and custom made Gadolinium markers placed on the surface of the heart to simplify and speed up prescription of the imaging planes. RF power was delivered at positions identified by the markers. All images were acquired using either a dark-blood prepared 2D HASTE or dark-blood prepared TSE sequence with the following parameters - TE: 49/60/64; Slice thickness: 3/3/5; resolution: 1.25x1.25/1.0x1.0/0.67x0.67; for the three experiments respectively. RF power was delivered either on the epicardial surface of the ventricle (the first 2 experiments – with the dog just outside the bore of the scanner) or on the endocardial right atrial appendage using the catheter (in the bore of the magnet). The animal was then re-positioned to image immediately post ablation. The animals were then euthanized and the heart excised for photography and visual examination of the lesions. The tissue samples were then sent for confirmatory histo-pathological analysis.

Results: Figure 1 shows a sample of the images acquired. The columns indicate the three different experiments (the first two being epicardial ablation), the rows indicate the images acquired pre, post and corresponding excised tissue respectively. The RF power delivered and the delivery duration are also indicated.

Figure 1. Images acquired from the 3 canine experiments with their observations.



Conclusion/Discussion: In each experiment, the images reveal the acute lesion as soon as a minute after it is created, without contrast injection, using T2-weighted sequences. Note that the time post ablation for the first 2 experiments is longer than a minute owing to the fact that the animal had to be positioned back in the scanner after ablation and then imaged. The ablation produced acute lesions could be visualized in the atrium as well. The third column in Fig. 1 shows the ablation in the septum between the right and left atrium.

These are preliminary results from experiments with a lot of unresolved problems ranging from proper ECG gating, RF power delivery in the MRI environment to real-time tracking coils and temperature feedback/measurements from ablation. Also, some of the applied lesions could not be seen with MRI. Future work will involve improving the performance of MRI compatible catheters including better tracking and imaging coils for real time ablation in the LA, and improving the performance of imaging sequences at 3T.

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