Assessment of Acute Cryo and RF Ablation Lesions by Non-contrast and Contrast Enhanced MRI Techniques: Similarities and Differences

Eugene G. Kholmovski[1], Ravi Ranjan[2], Joshua Silvernagel[2], and Nassir F. Marrouche[2]
[1]*UCAIR, Department of Radiology, University of Utah, Salt Lake City, Utah, United States,* [2]*CARMA Center, University of Utah, Salt Lake City, Utah, United States*

Target Audience
Scientists and clinicians interested in MRI techniques for cardiac RF and cryo-ablation procedures.

Purpose
Catheter radio-frequency (RF) and cryo-ablations are being increasingly used for treatment of atrial fibrillation and ventricular tachycardia. However, reported success rate of the procedures is moderate. The main causes of procedure failure are tissue recovery and gaps in ablation. The extent of ablations and lesion permanency cannot be accurately evaluated by conventional electro-physiological (EP) measurements. MRI can be used to assess lesion dimensions and to predict their permanency. Different sets of MRI techniques may be required for assessment of cardiac lesions created by different energy sources. In this study, we have compared visibility of acute cryo and RF ablation lesions using non-contrast and contrast enhanced MRI techniques.

Methods
Cryo and RF ablations of left and right ventricles of canines (n=4, weight=27-37 kg) were performed in the EP suite according to protocols approved by the local IACUC. Cryo lesions were created using cardiac cryo-ablation catheter with 8 mm tip (Medtronic CryoCath, Montreal, Canada) with freeze times of 2 and 4 minutes. RF lesions were created by RF ablation catheter with 4 mm tip (ThermoCool, Biosense-Webster, Diamond Bar, CA) at 30 Watts for 30 seconds. At the end of the ablation procedure in the EP suite, each animal was moved to the MRI suite. The time lapse between the end of ablation procedure in the EP suite and the animal in the MRI suite was less than an hour. MR imaging was performed using a 3 Tesla MRI scanner (Verio, Siemens Healthcare, Erlangen, Germany). Imaging protocol included T1, and T2 mapping, double inversion recovery (DIR) prepared T2w TSE, 3D T1w, followed by Gd-BOPTA (0.15 mmol/kg, Bracco Diagnostic Inc., Princeton, NJ) and post-contrast 3D T1w and 3D LGE. T1w and LGE scans were repeated at different time points after contrast injection. The animals were imaged at 1 week, 2 weeks, 1 and 2 months after ablation. 3-month after initial ablation, each animal was re-ablated and MRI study was repeated. At the end of this study animal was euthanized and the heart extracted for macroscopic and histological examination.
The parameters for the different scans were as follows. Non-contrast T1w - respiratory navigated, ECG triggered, saturation recovery prepared 3D GRE sequence with TR/TE=3.1/1.4 ms, flip angle=12^o, TI=400 ms, and voxel size=1.25x1.25x2.5 mm. Non-contrast T2w - respiratory navigated, ECG triggered, DIR prepared 2D TSE pulse sequence with TE=81 ms, TR=3 cardiac cycles, echo train length=21, fat suppression using SPAIR, in-plane resolution of 1.25x1.25 mm, slice thickness of 4 mm. Post-contrast T1w - respiratory navigated, ECG triggered, saturation recovery prepared 3D GRE with resolution=1.25x1.25x2.5 mm, TR/TE=3.1/1.4 ms, flip angle=15^o, and TI=150 ms. LGE - respiratory navigated, ECG triggered, inversion recovery prepared 3D GRE with resolution=1.25x1.25x2.5 mm, TR/TE=3.1/1.4 ms, flip angle=14^o, TI=230=330 ms.

Results
Representative T1w, T2w, and post-contrast T1w and LGE images of acute cryo and RF lesions are shown in Fig. 1. RF lesions were readily detectable on non-contrast T1w images. No cryo lesions were found on non-contrast T1w images (Fig. 1a). Degree and extent of post-ablation edema assessed by T2w images was noticeably different for cryo and RF ablations (Fig. 1b). Edema was very apparent and extended widely beyond lesion core for RF ablations while it was less apparent and mainly restricted to lesion core for cryo ablations. Appearance of cryo and RF lesions was similar in post-contrast T1w and LGE images (Fig. 1c, 1d). Presence of microvasculature obstruction (no-reflow) was evident for cryo and RF lesions at post-contrast T1w and LGE images acquired less than 30 minutes after contrast injection (Fig. 1c). Enhancement of edema region surrounding RF and cryo lesion core was observed on earlier (< 5 minutes) post-contrast T1w images (Fig. 1c).

Discussion and Conclusion
Post-contrast T1w and LGE MRI demonstrated that cryo and RF ablations similarly affect kinetics of MRI contrast in ablated regions: significantly slower wash-in and wash-out in lesion core than that of healthy tissues. Both types of ablations resulted in presence of microvasculature obstruction at lesion core. However, cryo and RF energies have different effects on native T1 and T2 relaxation time of ablated regions. RF ablation reduces T1 of lesion core while cryo ablation minimally affects T1 of ablated region. Both RF and cryo ablations result in increased T2 of affected region. However, change is more pronounced for RF ablations. This study has shown that native T1w MRI is useful for assessment of acute RF ablations. However, this imaging technique is not applicable for cryo ablations. Edema caused by cryo and RF ablations can be visualized by both T2w and earlier (3-5 minutes) post-contrast T1w scans. It was found that RF ablations result in more apparent and extended edema than edema caused by cryo ablations

Acknowledgments: This study was supported in part by Biosense-Webster.

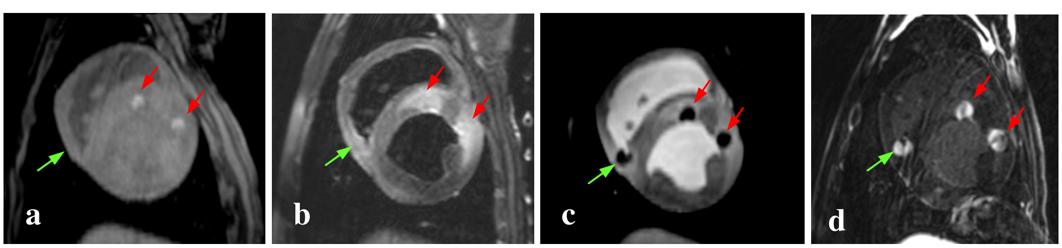

Figure 1. Representative pre-contrast T1w (**a**) and T2w (**b**), and post-contrast T1w (**c**) and LGE (**d**) images of acute cryo and RF ablation lesions. Red arrow – RF lesion, green arrow – cryo lesion. Post-contrast T1w was performed 3 minutes after contrast injection. LGE was acquired 55 minutes after the injection.