

MRI appearance of time-separated RF ablation lesions

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Abstract: Cardiac Electrophysiology (EP) procedures involve thermal (radiofrequency, RF) ablations of the arrhythmia substrate and surrounding myocardium. The contiguity and transmurality of the ablation lesions ought to be monitored by MRI to ensure long-term procedure success (1). Previous studies (e.g., 2, 3) investigated MRI visualization aspects of quasi-simultaneous lesions created few minutes apart. However, in some clinical EP procedures lesion creations can be separated in time by dozens of minutes. There is a chance that different appearances on MRI of lesions created at different time instants would complicate intra-operative interpretation of MRI and require additional image processing efforts to make MRI of ablation lesions suitable for intra-operative usage during EP procedures. This work examines the MRI appearance of ablation lesions created 15-45 min apart and imaged shortly after the creation of the last lesion. It demonstrates that the lesions separated by typical (for clinical EP procedures) time intervals look similar when imaged using standard MRI approaches. Thus, the typical clinical time span between ablation lesions poses no challenge for intra-operative lesion visualization and MR image interpretation.

Methods: This animal study was approved by the animal care committee of Sunnybrook Health Sciences Centre. Using clinical EP catheters, 24 RF lesions were created in the Latissimus dorsi muscles of 6 rabbits (35 Watt for 45 sec). Initial and final catheter tip temperature together with the final electrical impedance were recorded during each ablation. Four lesions were created in each animal at time interval of 15 min between ablations, so that creation of the first and last lesions was separated by ~45 min. 10-30 min after the last lesion was created, the sedated animals were positioned inside a standard transmit-receive birdcage head coil of a 1.5T MRI scanner and underwent imaging using high-resolution 3D T1w, T2w, Steady State Free Precession (SSFP) and Delayed Enhancement (DE) scans. DE data was acquired twice – immediately before and ~10 min after animals were injected with 0.1 ml/kg of Gadovist. T1w data was acquired using Fast RF-Spoiled Gradient Echo (FSPGR) with in-plane resolution of 0.31 x 0.63 mm (reconstructed to 0.31 x 0.31 mm), TR/TE/FA of 20.3ms/9.9ms/45deg, 8 averages, and scan time of 7 min 38 sec. T2w data was acquired using Fast Spin Echo (FSE) with in-plane resolution of 0.31 x 0.63 mm (reconstructed to 0.31 x 0.31 mm), TR/TE of 900ms/26.8ms, echo train length of 24, 4 averages, and scan time of 7 min 57 sec. SSFP data was acquired using FIESTA with in-plane resolution of 0.31 x 0.42 mm (reconstructed to 0.31 x 0.31 mm), TR/TE/FA of 14.5ms/4.2ms/30deg, 8 averages, and scan time of 8 min 12 sec. DE data was acquired using Inversion Recovery (IR) FSPGR with in-plane resolution of 0.42 x 0.75 mm (reconstructed to 0.31 x 0.38 mm), TI/TR/TE/FA of 200ms/15.7ms/7.5ms/25deg, 6 averages, and scan time of 8 min 27 sec. In all scans, RBW of 15.6 kHz and the Extended Dynamic Range (EDR) option (which enables 32-bit data processing resulting in SNR improvement) were used; also, 18 1.2-mm thick slices with zero spacing were acquired and reconstructed to 72 1.2-mm thick slices with 0.9 mm overlap. The images were reformatted and reviewed on a radiology image analysis work station. Pre-injection DE data was subtracted from the corresponding post-injection data to enhance lesion visibility.

Results: No substantial differences in the appearance between lesions ablated at different times were detected in all acquired images. Some differences in the size of lesions were observed, which did not correlate with the time of ablation but rather with final electrical impedance measured during energy application (the lower the final impedance the bigger lesion). Some lesions demonstrated on SSFP images susceptibility-like artefacts, which may have been caused by interstitial bleeding or formation of vapour cavities. Frequently, such lesions also demonstrated irregularities on T1w and T2w images. DE images provided the most sharp and distinctive depiction of lesion borders but there were no differences in border appearance between lesions ablated at different times. Fig. 1 depicts typical images for the reported study.

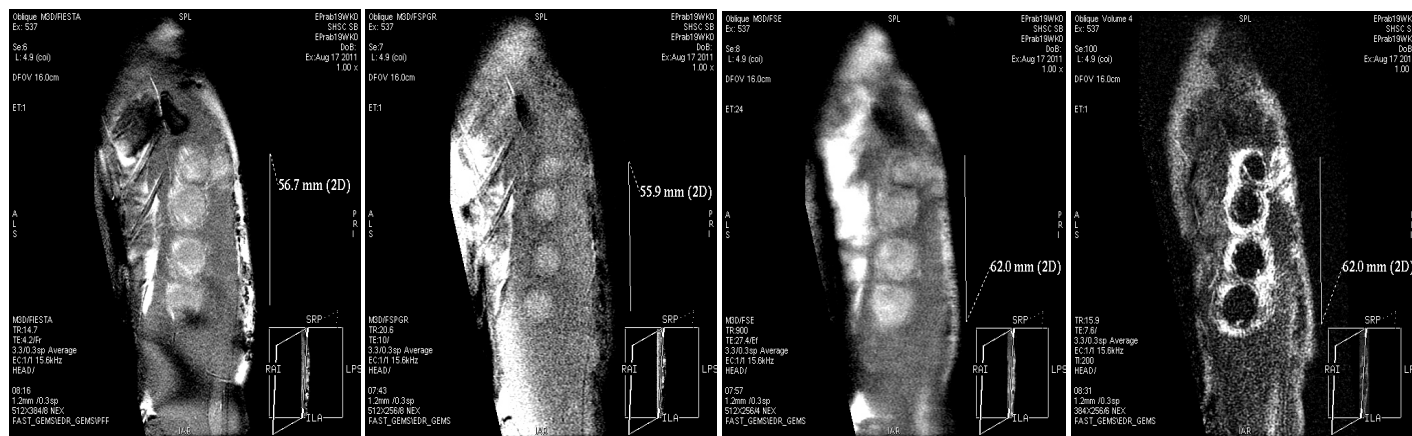


Fig. 1: Typical SSFP (far left), T1w (middle left), T2w (middle right) and subtracted DE (far right) images of ablation lesions acquired during the study. The most superior lesion was ablated first; each subsequent lesion was ablated in an adjacent position 15 min after the previous one.

Discussion: Time gaps between ablation lesions of ~30-45 min represent well the time differences between lesions ablated over a typical clinical EP procedure. As our results suggest, the time gaps do not influence MRI appearance of the lesions, so lesions created during a clinical EP procedure can be imaged at once using any of the described techniques. No special image post-processing or interpretation is required when even creation of ablation lesions is separated by up to 45 min; the resulting lesions appearing in the same FOV on T1w, T2w, SSFP and DE images have similar features.

References: 1. VY Reddy et al.; J. Cardiovasc. Electrophysiol. 2008; 19(4): 434-437. 2. T Dickfeld et al.; Heart Rhythm 2007; 4: 208-214. 3. T Dickfeld et al. J. Am. Coll. Cardiol. 2006; 47: 370-378.