

## MRI of acute atrial lesions: Immediately vs. next day post RF ablation MRI in patients with atrial fibrillation

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**Introduction:** Atrial fibrillation (AF) is the most common cardiac rhythm disturbance affecting more than 2 million people in North America. Radio-frequency (RF) catheter ablation of the left atrium (LA) is effective for symptomatic, drug refractory AF patients. Reported success rates of the procedure vary significantly with AF recurrences ranging from 25-60%. The main causes of AF recurrence are tissue recovery and gaps in desired ablation patterns. Double inversion recovery (DIR) prepared T2-weighted (T2w) fast/turbo spin echo (FSE/TSE) and HASTE [1-4] and late gadolinium enhancement (LGE) [5-8] have been used to evaluate acute LA wall injury and predict post-ablation scar. However, how soon after conclusion of the ablation procedure should an MRI study be performed, to get better visibility of acute atrial injury and achieve a reliable validation of atrial tissue destruction remains unknown. In this study, we compare visibility of acute atrial injuries in LGE and DIR-T2w-TSE MRI studies performed immediately (< 2 hour) and the next day after RF ablation procedure.

**Theory and Methods:** From January 2010 to October 2011, 232 AF patients who underwent RF ablation under 3D EAM guidance (CARTO, Biosense Webster) were moved to 3 Tesla Verio scanner (Siemens Healthcare, Erlangen, Germany) after the conclusion of the ablation procedure. Typical time interval between the conclusion of procedure and patient in the scanner was less than an hour. These MRI studies were performed to rule out procedure complications and to assess the extent of injury to LA wall. The study protocol included DIR-prepared T2w TSE and HASTE, contrast enhanced MR angiography (0.1 mmol/kg, Multihance (Bracco Diagnostic Inc., Princeton, NJ)), and 3D LGE scans. 12 out of these 232 patients underwent an additional MRI study on the next day after ablation (22.0±2.5 hours) to follow-up on significant enhancement of the anterior wall of the esophagus in the vicinity of LA wall, detected by immediately post-ablation LGE-MRI. All these 12 patients underwent similar ablation procedure: pulmonary vein isolation in addition to debulking LA posterior wall and septum [9].

Contrast-to-noise ratio (CNR) between LA lesion and blood ( $CNR_{LB}$ ) and between LA lesion and normal myocardium ( $CNR_{LM}$ ) were evaluated for these 12 patients using immediately and next day post-ablation DIR-T2w-TSE and LGE images. Measurements were performed in similar anatomical locations for immediately and next day post-ablation images. Signal intensities for blood, normal myocardium, and atrial lesions were measured in the LA cavity, the LV wall adjacent to LA, and LA posterior wall, respectively. The regions of no-reflow presented on immediately post-ablation LGE images [7,8] were excluded from the analysis. Standard deviation of noise for CNR calculation was assumed to be equal to standard deviation of blood signal in the LA cavity.

Post-ablation edema was visualized using 2D DIR-TSE with the following parameters: TE=83ms, TR=2RR, ETL=21, fat suppression using SPAIR, in-plane resolution of 1.25x1.25 mm, slice thickness of 4 mm, 20 slices, GRAPPA with R=2 and 42 reference lines. Typical scan time was 6 minutes.

High resolution LGE images of LA were acquired about 15 minutes after contrast agent injection using a 3D respiratory navigated, inversion recovery prepared GRE pulse sequence with TR/TE=1.4/3.1 ms, flip angle of 14°, bandwidth=750 Hz/pixel, FOV=400x400x110 mm, matrix size=320x320x44, voxel size=1.25x1.25x2.5 mm. Inversion pulse was applied every heart beat and fat saturation was applied immediately before data acquisition. Data acquisition was limited to 15% of RR cycle and was performed during LA diastole. Typical scan time for LGE study was 4-8 minutes depending on patient respiration pattern.

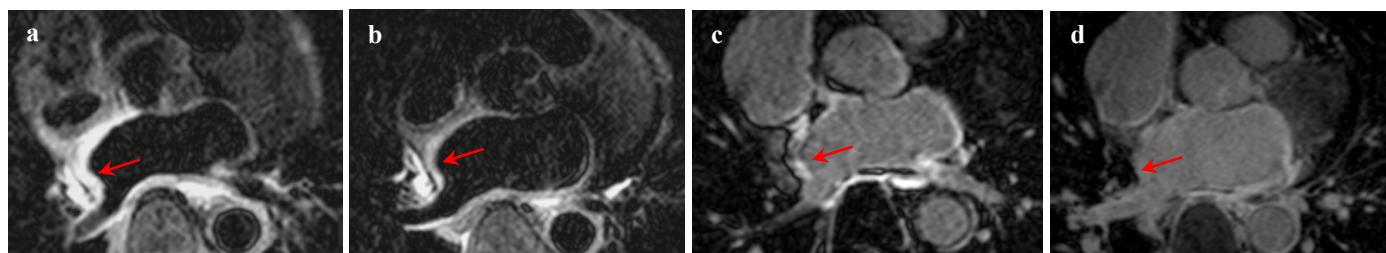
**Results:** Typical DIR-T2w-TSE and LGE images acquired immediately and next day after ablation are shown in Figure 1. Appearance of ablated LA regions changes drastically with time after ablation. On immediately post-ablation DIR-T2w-TSE and LGE images, injured regions are hyper-intense and easily detectable (Fig. 1a, 1c). Some of these regions continue to be detectable on next day post ablation images (Fig. 1b, 1d). However, contrast between them and surrounding tissues is low. Quantitative analysis (Table 1) of the DIR-T2w-TSE and LGE images demonstrates that contrast between ablated regions of LA wall and the other tissues is significantly higher in immediately post-ablation images than in the next day post-ablation images.

Table 1	DIR-T2w-TSE			LGE		
	Immed. Post	Next Day	p-value	Immed. Post	Next Day	p-value
$CNR_{LM}$	16.86±3.22	10.09±5.02	0.002	17.29±3.34	12.22±2.69	0.0005
$CNR_{LB}$	22.95±4.43	15.59±6.19	0.0057	9.62±2.71	4.08±2.63	0.00005

**Discussion and Conclusion:** The presented results indicate a fast physiological response of LA wall to injury. Edema is noticeably reduced 24 hours post-ablation. Kinetics of contrast agent in injured regions changes considerably during the first 24 hours after ablation. Ablated regions of LA wall are easily detectable in immediately post-ablation LGE scans. Whereas, detection of ablated regions is problematic in many of next day post-ablation LGE scans because of a weak contrast between ablated regions and blood. Our results demonstrate that MRI study should be performed as soon as possible after conclusion of the RF ablation procedure to achieve high contrast between ablated LA wall and the surrounding tissues.

**Acknowledgments:** This study was supported in part by MRI Interventions Inc., Ben B. and Iris M. Margolis Foundation.

**References:** [1] Vijayakumar S, et al., JCMR 2009;11:214. [2] Knowles BR, et al., ISMRM 2009, 487. [3] Peters DC, et al., ISMRM 2009, 4433. [4] Kholmovski EG, et al., JCMR 2010;12:P97. [5] Peters D, et al., Radiology 2007;243:690-5. [6] McGann CJ, et al., JACC 2008;52:1263-71. [7] Kholmovski EG, et al., ISMRM 2011, 3732. [8] McGann CJ, et al., JACC 2011;58:177-85. [9] Segerson NM, et al., J Cardiovasc Electrophysiol 2010;21:126-32.



**Figure 1.** DIR-T2w-TSE (a, b) and LGE (c, d) images of AF patient. (a, c) – immediately post-ablation, (b, d) – next day post-ablation. Notice high contrast between ablated regions of LA wall (posterior wall, septum, ostium of right posterior PV) and myocardium of the left ventricle and blood in immediately post-ablation DIR-T2w-TSE and LGE images.