Radiofrequency Ablation Characterization: Comparison of Multi-Contrast Late Enhancement and Late Gadolinium Enhancement Sequences

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TARGET AUDIENCE:

Clinicians and scientists studying MR for arrhythmia management

PURPOSE:

Cardiologists treat arrhythmias, which are the results of abnormal electrical pulses in heart, by creating radiofrequency ablation (RFA) lines under the guidance of x-ray. Although x-ray is accurate for catheter visualization, its soft tissue contrast is insufficient to visualize RFA lesions. The late Gd-DTPA enhancement (LGE) method has been used for characterization of RFA lesions[1].

Here, the multi-contrast late enhancement (MCLE)[2] technique was proposed for a more robust characterization of the RFA lesions. The MCLE method provides images with varying contrast and quantitative T_1^* and steady-state maps, derived from these MCLE images.

METHODS:

Under an institutionally approved animal protocol five endocardial lesions were created in the left ventricle of three pigs under x-ray fluoroscopy guidance *(OEC 9800, GE Healthcare, Salt Lake City, Utah)*. A Stockert 70 RF generator was used to deliver 35 Watts for 45 seconds through a 2.7mm (8F) Navistar irrigated catheters; the EP signal was monitored using CARTO XP *(BiosenseWebster, Diamond Bar, CA)*. The MRI was performed using a 1.5T scanner *(Signa HD, General Electric, USA)* and the four channel cardiac phased array coil. ECG gating and controllable breath holds were used for compensating the cardiac and respiratory motions, respectively. After injecting Gd-DTPA (Magnevist, 0.2 mmol/kg) the MCLE *(FOV=24cm, slice thickness: 5mm, TR/TE=4/1.7ms, readout bandwidth=83.3kHz, matrix=192×160, inversion time=604ms-652ms)* and the LGE *(FOV=24cm, slice thickness: 5mm, TR/TE=3.8/2.7ms, readout bandwidth=15.3kHz, matrix=192×160, inversion time=600ms)* images were acquired repeatedly for about 45min. The contrast-to-noise ratio (CNR) was measured as the signal intensity of the lesion minus the signal intensity of the adjacent myocardium over the standard deviation of the background noise. The corresponding MCLE images used for CNR and size measurements were chosen to match LGE images.

Figure: LGE image (a), MCLE image (b and d), T_1^* map (c), steady-state map (e), and size comparison plot (f).
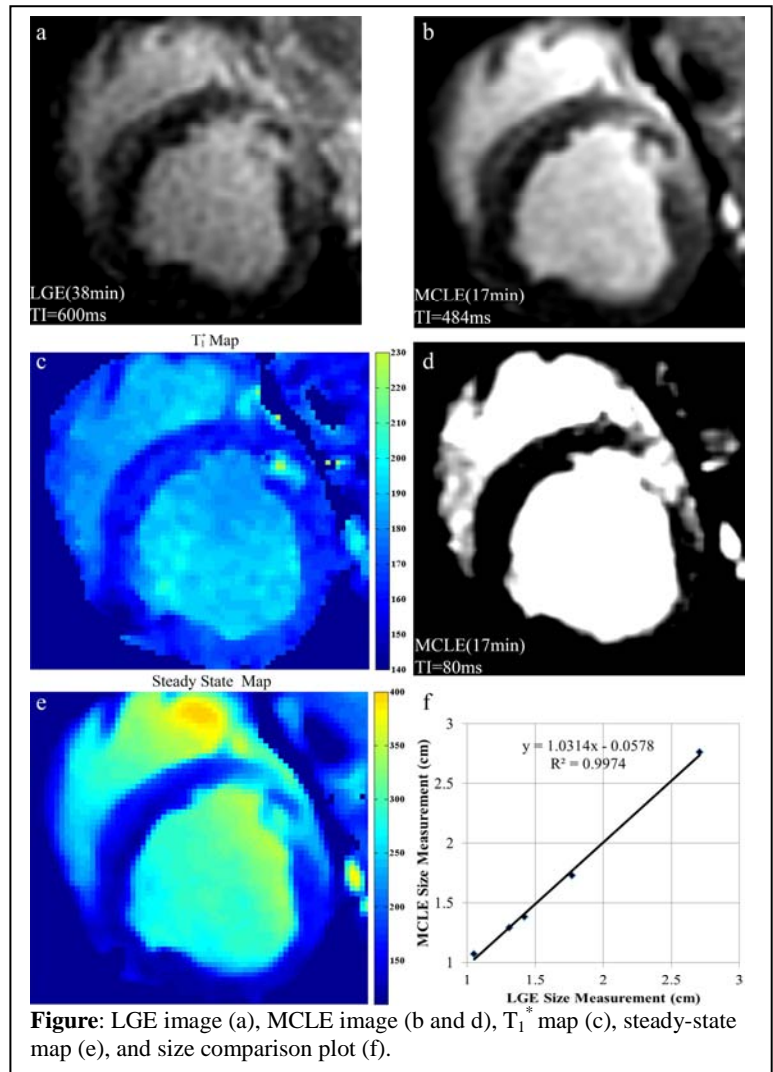
RESULTS:

The Figure shows images of an RFA lesion in the anterior wall using the LGE (Fig. a) and the MCLE (Figs. b and d) methods, as well as the T_1^* (Fig. c) and the steady-state (Fig. e) maps. Also, the plot (Fig. f) shows the lesion size measurement comparison of MCLE and LGE as statistically equivalent and highly correlated (slope=1.0314, R2=0.9974). CNR values of MCLE and LGE methods were (19.88±1.28) and (9.56±1.97) respectively.

DISCUSSION:

Both methods demonstrated similar lesion structures which consisted of the hyper-enhanced rim around the hypo-enhanced lesion core (Figs. a and b). The MCLE method outperformed the LGE technique by yielding both the multi-contrast images in one breath-hold (Figs. a and d) and the quantitative relaxometry maps (Figs. c and e). CNR values of the MCLE images were significantly better than the LGE images. Steady state maps showed that healthy myocardium and the lesion core had lower values compared to the region around the lesion core, which probably reflects the edematous response of the heart. The T_1^* map indicated that the lesion core had higher values compared to healthy myocardium and edematous regions (Fig. c).

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