Synthetic LGE Derived from Cardiac T1 Mapping for Simultaneous Assessment of Focal and Diffuse Cardiac Fibrosis

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Introduction: While late gadolinium enhanced (LGE) MRI is the gold standard for detection of focal myocardial scarring[1], it is less effective than cardiac T1 mapping (extracellular volume fraction, ECV[2]) for detection of diffuse fibrosis. LGE, in principle, can be synthesized from post-contrast cardiac T1 maps. We sought to derive synthetic LGE images from saturation-recovery based post-contrast cardiac T1 maps for simultaneous assessment of focal and diffuse cardiac fibrosis.

Methods: We imaged six mongrel dogs with lesions created by RF ablation on a 3T MRI system (Verio, Siemens), using arrhythmia-insensitive-rapid (AIR) cardiac T1 mapping[3] and standard LGE MRI during equilibrium of Gd-BOPTA (slow infusion at 0.002 mmol/kg/min), in order to compare standard and synthetic LGE images acquired at identical concentration of Gd-BOPTA. Both standard LGE MRI and post-contrast cardiac T1 mapping were acquired with identical spatial resolution = 1.4 mm x 1.4 mm x 7.0 mm. After calculating the AIR cardiac T1 maps, as previously described[3], a synthetic LGE image was subsequently synthesized using the Bloch equation describing an ideal inversion recovery: $Mz = 1 - 2*\exp(-TI/T1)$, where Mz is the longitudinal magnetization, inversion time (TI) to null the normal myocardium was calculated by rearranging the above equation as $TI = T1_M \times \ln(2)$, where $T1_M$ is the mean T1 of normal myocardium. For quantitative analysis, we calculated the contrast ratio defined as the difference of signal intensity (e.g., lesion-myocardium) divided by the signal intensity in lesion (see Table1). Same analysis was performed for the blood-myocardium pair. This analysis enabled us to compare standard and synthetic LGE data sets with different intensity scales. Pair-wise t-test was used to compare the two groups (standard vs. synthetic LGE).

Results: Our pooled data contained 21 short-axis planes with different RF lesions. Figure 1 shows representative standard and synthetic LGE images with a lesion, which show comparable image quality. As summarized in Table 1, synthetic LGE yielded higher ($p < 0.0001$) contrast ratio of the lesion-myocardium and blood-myocardium pairs than standard LGE, but the magnitude of the differences (percent change) was less than 10%.

Discussion: We propose a new approach to simultaneously assess focal and diffuse cardiac fibrosis using cardiac T1 mapping, with no need for separate acquisition of standard LGE images. This approach is also compatible with inversion-recovery based cardiac T1 mapping methods. Synthetic LGE derived from post-contrast cardiac T1 mapping may be particularly useful for infarct size and area at risk calculations, because it is inherently insensitive to signal variation due to confounders such as RF excitation and receive inhomogeneities.

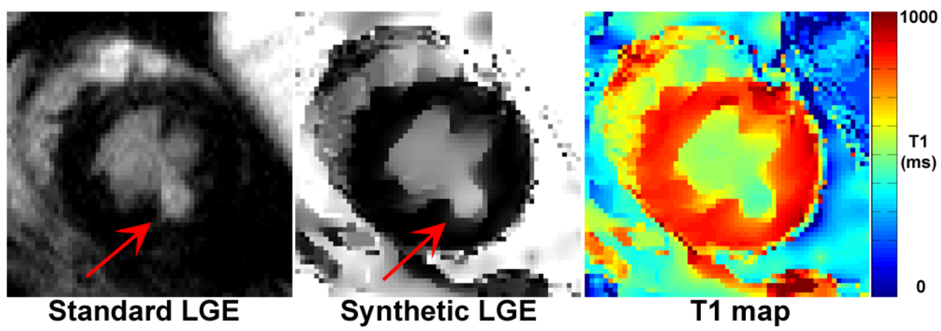

Figure 1. Comparison of (left) standard LGE and (middle) synthetic LGE derived from (right) post-contrast T1 map. Red arrows point to RF ablation lesion created hours before with a catheter.

Table 1. Summary of contrast ratio of lesion-myocardium and blood-myocardium pairs for 21 short-axis planes with RF lesions.

Tissue Pair	Standard LGE (%)	Synthetic LGE (%)	p-value (t-test)	Percent Change (%)
lesion vs. myocardium	**89.8 ± 4.2**	**96.1 ± 2.2**	**< 0.0001**	**7.02**
blood vs. myocardium	**88.1 ± 4.8**	**95.9 ± 2.4**	**< 0.0001**	**8.85**

References:

1. Kim RJ et al., *Circulation* 1999;100:1992-2002.
2. White SK et al., *JACC Cardiovasc Imaging* 2013;6:955-62.
3. Fitts M et al., *MRM 2013;*70:1274-82.