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Synthetic LGE derived from cardiac T_1 mapping for simultaneous assessment of focal and diffuse cardiac fibrosis

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Background

While late gadolinium enhanced (LGE) MRI is the gold standard for detection of focal myocardial scarring [1], it is less effective than cardiac T_1 mapping (ECV) for detection of diffuse fibrosis. LGE, in principle, can be synthesized from cardiac T_1 maps. We sought to derive synthetic LGE images from saturation-recovery based cardiac T_1 maps for simultaneous assessment of focal and diffuse cardiac fibrosis.

Methods

We imaged 6 mongrel dogs with lesions created by RF ablation on a 3T MRI system (Verio, Siemens), using arrhythmia-insensitive-rapid (AIR) cardiac T_1 mapping [2] 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 LGE MRI and cardiac T_1 mapping were acquired with identical spatial resolution = 1.4×1.4×7 mm. After calculating the AIR cardiac T_1 maps, as previously described[2], a synthetic LGE image was subsequently synthesized using the Bloch equation describing an ideal inversion recovery: $M_z = 1 - 2^*\exp(-TI/T_1)$, where M_z is the longitudinal magnetization, inversion time (TI) to null the normal myocardium was calculated by rearranging the above equation as $TI = T_{1M} \times \log(2)$, where T_{1M} is the mean T_1 of normal myocardium. For quantitative analysis, we calculated the contrast ratio, as defined as the signal difference (e.g., lesion-myocardium) divided by lesion (see Table 1). 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. Pairwise 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. The two LGE images showed comparable image quality. As summarized in Table 1, synthetic LGE yielded higher ($p < 0.001$) contrast ratio of the lesion-myocardium and blood-myocardium pairs than standard LGE, but the magnitude of the differences was less than 10%.

Conclusions

We propose a new approach to simultaneously assess focal and diffuse cardiac fibrosis using cardiac T_1 mapping, with no need for separate acquisition of standard LGE images. This approach is also compatible with inversion-recovery based cardiac T_1 mapping methods. Synthetic LGE derived from T_1 mapping may be particularly useful for infarct size and area at risk calculations, because it is inherently

Table 1 Summary of contrast ratio of lesion-myocardium and blood-myocardium pairs.

Tissue Pair	Standard LGE (%)	Synthetic LGE (%)	p-value	Percent Change (%)
Lesion vs. Myocardium	89.8 ± 4.2	96.1 ± 2.2	< 0.001	7.0
Blood vs. Myocardium	88.1 ± 4.8	95.9 ± 2.4	< 0.001	8.9

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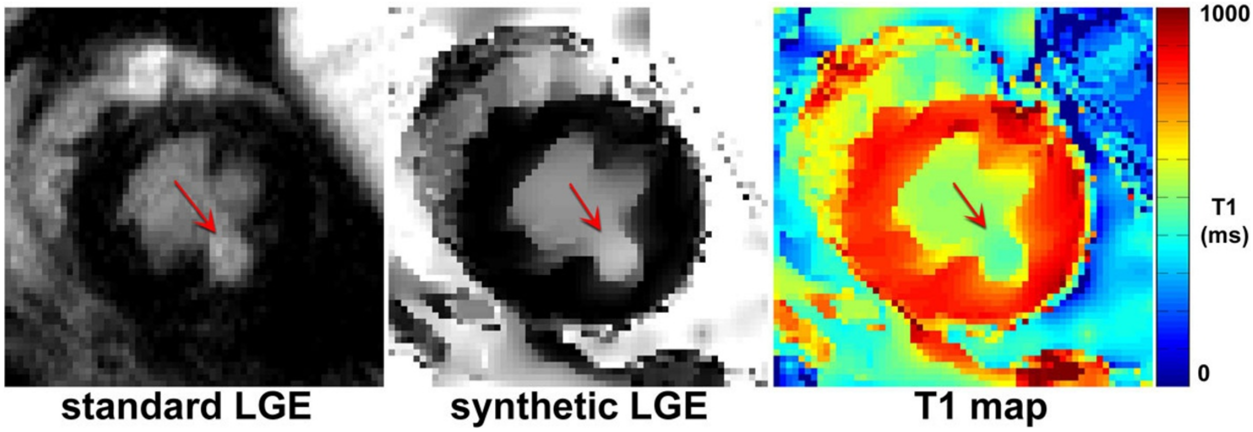

Figure 1 Comparison (left) standard LGE with (middle) synthetic LGE derived from (right) T_1 map. Red arrows point to RF ablation lesion created hours before with a catheter.

insensitive to signal variation due to confounders such as RF excitation and receive inhomogeneities.

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