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Towards refining the definition of grey zone for late gadolinium enhancement

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Introduction

Grey zone on late gadolinium enhancement images (LGE) is quantified using signal intensity (SI) (1,2). However, LGE signal depends on heart-rate and TI choice, and the noise.

Purpose

To demonstrate that grey zone and scar quantified on LGE depend on image SNR and inversion time (TI), and to use T_1-mapping to assess the normal range of post-contrast T_1 values in the heart, for improved detection of grey zone.

Methods

Phantom studies

A collection of phantoms (505-302 ms T_1s, in 50 ms increments) with known T_1s were imaged using LGE sequences, with scan parameters: 1RR between inversions, TR/TE/θ = 5.7 ms/3.4 ms/20°, 1.5 × 1.5 × 5 mm, 20 views-per-segment, sequential order. The phantom with T1 = 505 ms represented "normal myocardium" and the phantom with T_1 = 302 ms represented "scar". The myocardial signal was nulled, and scar and grey zone thresholds were calculated using 50% of maximal SI (2) in scar and maximal SI in the "normal myocardium" (2). The LGE sequence was acquired at higher SNR, and at optimal TI and optimal TI ± 30 ms.

T1 mapping

An ECG-gated T1 map was obtained using the LGE multiple TI approach (3) in 3 healthy subjects and one patient (age 36 ± 19 years), 20-25 minutes after 0.2 mmol/kg injection of Gd-DTPA. A two-parameter non-linear least-squares fit was applied to the data in Matlab.

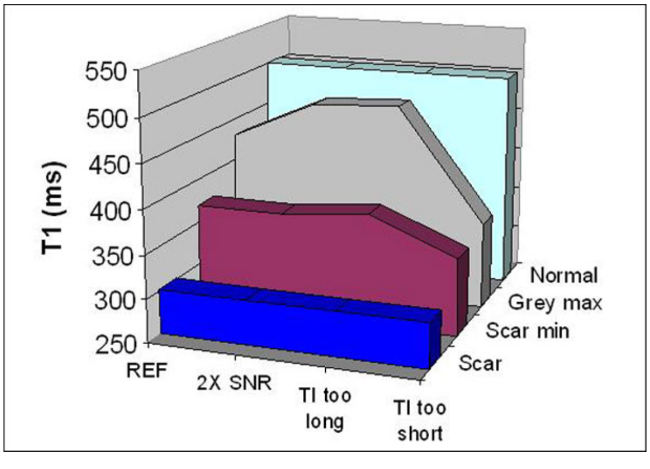

Figure 1
For LGE images with varied SNR and nulling, the relationship between T_1 values and scar and grey zone cutoffs is shown using SI based definitions, using phantom study. "REF" the standard optimally nulled image. SNR was increased by averaging ("2X SNR").

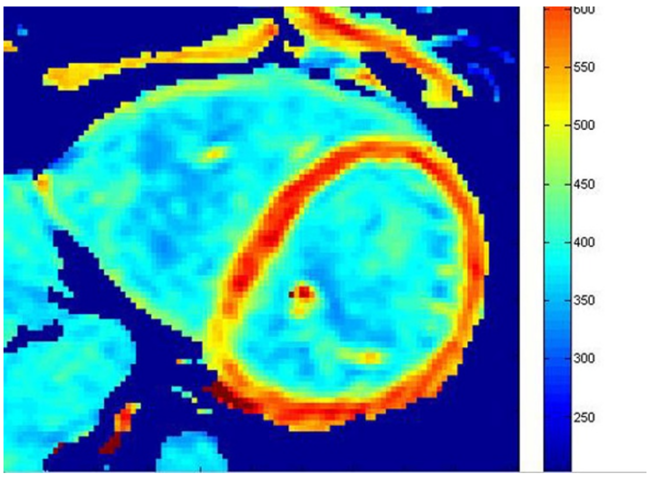

Figure 2
Representative T1 map in a health subject post contrast.

Results

Phantoms studies

Figure 1 shows the T_1s ranges included as "scar" and "grey zone" using the applied definitions, and how these ranges are affected by SNR and TI. The range of T1s designated as scar is unchanged except for an inappropriately short TI. Grey zone is affected by TI choice, and is also increased with increased SNR. This demonstrates that grey zone quantification is dependent on SNR and TI choice.

T_1 mapping

The accuracy of the T_1 mapping method in phantoms was 34.6 ± 12 ms (bias + 1SD). In the subjects without apparent scar (Figure 2), the T_1 mapping showed an average T_1 for blood and myocardium of 342 ± 37 ms, and 566 ± 18 ms, respectively and the average standard deviations were 20 ± 3 ms and 40 ± 11 ms, respectively.

Conclusion

Grey zone characterization by LGE depends on SNR and appropriate TI. Using T_1 mapping method, the range of T_1s in normal subjects has been measured. T1-mapping in patients will be a step towards refining the identification of grey zone using thresholds based on regional T_1 values.

References

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