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WORKSHOP PRESENTATION Open Access

Dynamic tracking of manganese uptake in mouse hearts by rapid multi-slice T_1 mapping

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Background

Manganese (Mn^{2+})-enhanced MRI (MEMRI) has the potential for in vivo assessment of the voltage-gated L-type Ca^{2+} channel activity. Quantitative assessment of Mn^{2+} uptake via Ca^{2+} channels requires fast and accurate T_1 mapping. In the current study, a multi-slice saturation recovery Look-Locker (MSRLL) method was developed for T_1 mapping of the whole mouse heart in < 3 min.

Methods

MSRLL Sequence

A schematic diagram of the MSRLL pulse sequence is shown in Figure 1. An ECG-triggered saturation module was applied at the beginning of each phase-encoding step, followed by the acquisition of k-space lines along the magnetization recovery curve in multiple slices. ECG-triggered image acquisition was performed at late diastole.

Phantom Study

All MRI studies were performed on a horizontal 7.0T Bruker scanner with a 35 mm volume coil. The MSRLL method was first validated in vitro using a multi-compartment phantom with $MnCl_2$ solution ranging from 30 μM to 1000 μM. T_1 maps of 5 slices were compared with those acquired with a previously validated single-slice method (SRLL). Imaging parameters were: flip

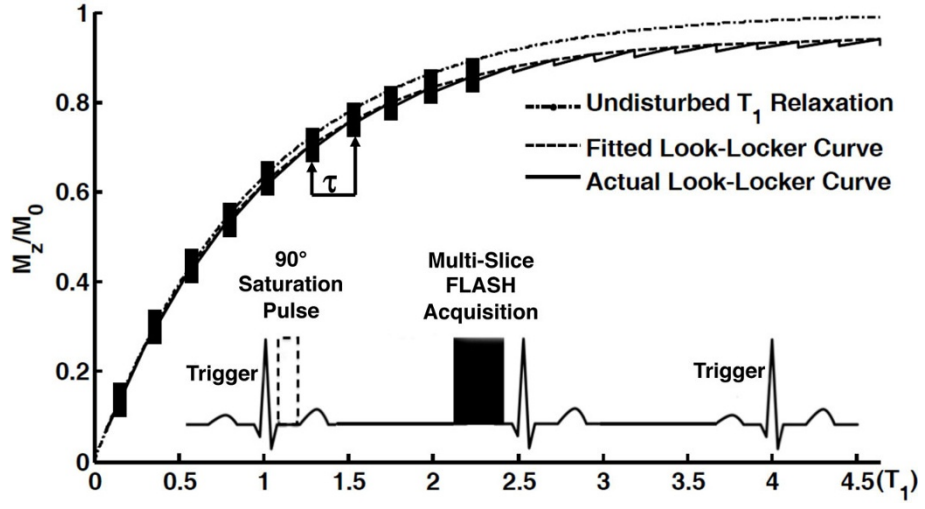

Figure 1 MSRLL pulse sequence. After 90° non-slice selective saturation pulses, 10 sequential multi-slice FLASH acquisitions separated by an interval τ were applied. Each block on the relaxation curve represents a multi-slice acquisition module.

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angle, 10°; TE, 1.9 msec; slice thickness, 1 mm; number of average, 1; field of view, 3 × 3 cm^2; matrix size, 128 × 64.

In Vivo Study

In vivo MEMRI studies were performed in 3-month-old FVB mice (n = 19). T_1 maps of three adjacent short-axis slices at mid-ventricular levels were acquired with the same imaging parameters as those used in vitro. Continuous T_1 mapping was performed during the 30 min of $MnCl_2$ infusion through tail vein (0.2 mL/hr) and the 15 minutes washout. To investigate the Mn^{2+}-induced relaxivity changes, two different $MnCl_2$ solutions at

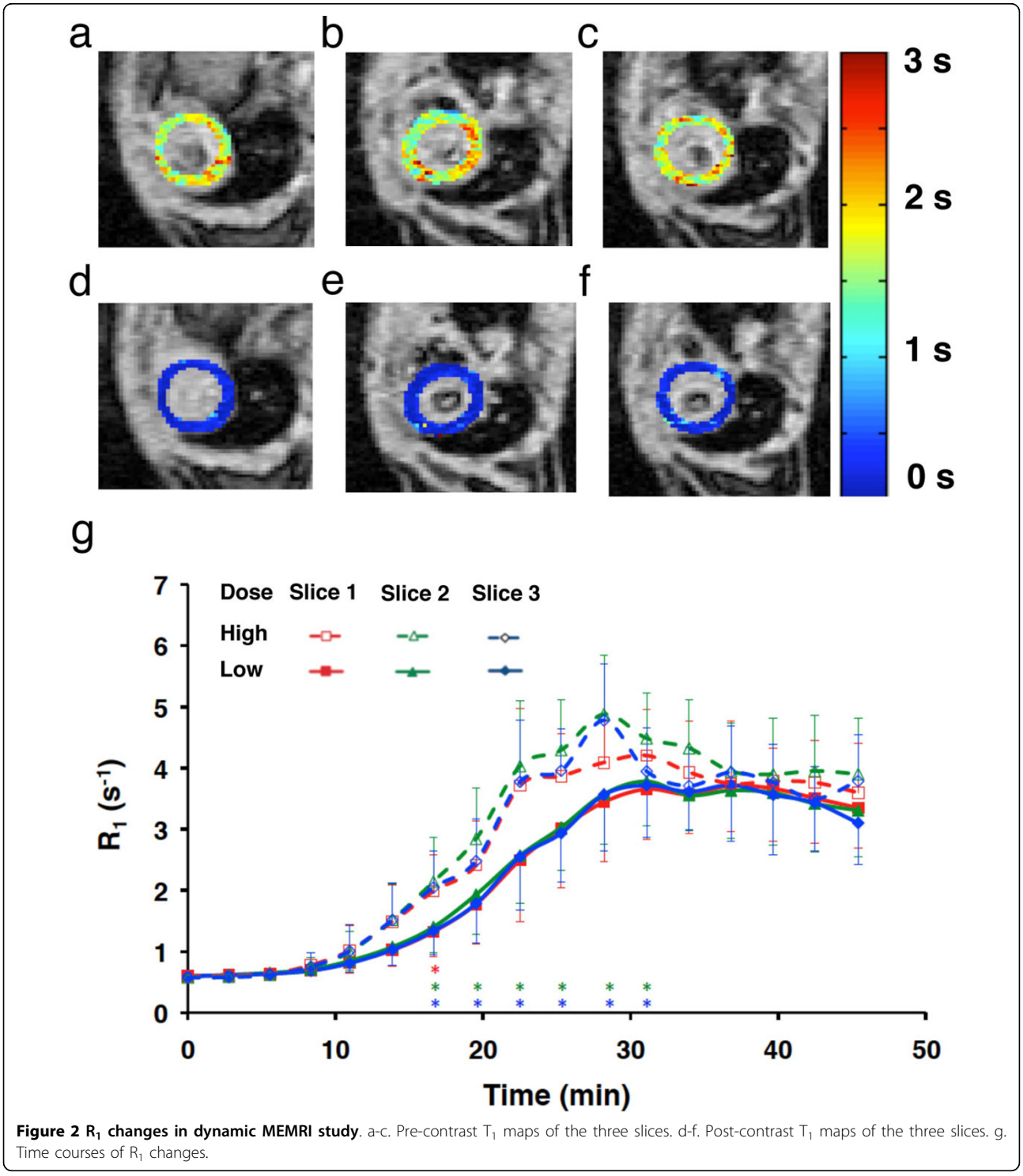

Figure 2 R_1 changes in dynamic MEMRI study. a-c. Pre-contrast T_1 maps of the three slices. d-f. Post-contrast T_1 maps of the three slices. g. Time courses of R_1 changes.

126 mM (n = 9) and 63 mM (n = 10) were used. Validation study was performed either at baseline (n = 10) or post-contrast (n = 10).

Results

In vitro studies showed strong agreement between MSRLL and SRLL. Average imaging time in vivo was 140~166 s. Shown in Figure 2 are representative T_1 maps acquired at baseline (Figure 2a-c) and after Mn^{2+} infusion (Figure 2d-f). All three slices showed significant reduction in T_1 after Mn^{2+} infusion. The time courses of the R_1 changes for all three slices are presented in Figure 2g. In general, higher Mn^{2+} dose induced larger increase in R_1 during Mn^{2+} infusion.

Conclusions

An ECG-triggered, multi-slice saturation-recovery Look-Locker method was developed for fast and complete cardiac T_1 mapping in mice. Validity and utility of this method was well demonstrated in the phantom and in vivo two-dose MEMRI studies.

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