Manganese Enhanced MP-RAGE Abdominal MRI

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Abstract

A preclinical animal model for abdominal imaging is essential in revealing many disorders which results in such pathologies as obstructive vena cava, renal vein thrombosis, portal vein obstruction, enlarged spleen, liver and pancreatic cancer. The peristaltic motion and ineffective respiratory gating are two limiting factors for non-invasive MR imaging especially in the rodent model. Although administration of chelated Mn such as Mn-DPDP has proven to be a useful clinical T1 contrast agent for liver imaging, and $MnCl_2$ has found popular use for animal research (1-3). We hypothesized that with faster imaging sequences we can obtain heavily T1-weighted images which enable us to detect subtle changes associated with a minimum dose of $MnCl_2$. We used three concentrations of $MnCl_2$ resulting in a total dose of 0.21, 1.31, and 2.51 (nmol/g BW). Pre and post contrast T1-weighted images were obtained using magnetization prepared rapid acquisition gradient echo (MP-RAGE) sequence. In-vivo data in rats indicate a combination of these two can result in significant signal enhancement and reduction in Mn dose. Pre and post contrast agent images reflect an enhancement in signal predominantly in the left lobe of the liver, intestine and pancreas. A signal enhancement of 18% in liver (left lobe) and 20% in pancreas (splenic region) was measured using low doses of $MnCl_2$.

Methods:

Sprague Dawley rats (270-320g; Charles River) were imaged on a 4.7T Bruker Biospec 33 cm horizontal bore with a home built birdcage coil. Animals were anesthetized with 2% gas isoflurane and intubated. The femoral vein was cannulated with PE-10 tubing for Mn infusion and vital signs were monitored via ECG, respiratory pad, and rectal thermometer using SA Instrument (Stony Brook, NY) software. Each animal was placed in a 6 cm birdcage coil with the abdominal region in the center of the coil. Three animals were infused with manganese chloride (5mM, 25mM, and 50mM) at 0.5ml/hr for 20 min giving a total dose of 0.21, 1.31 and 2.51 nmol/g BW and pre and post contrast T1-weighted images were obtained using MP-RAGE (FOV = 6.3 x 5.8 cm, matrix size = 160 x 160, echo time = 3.63ms, TR = 11.42 ms, inversion delay = 750 ms, 4 segments, segment duration = 457 ms. 8 averages, for a total acq time = 10min).

Results and Discussion:

The variability in the imaging pulse sequence and algorithms provide us multiple choices for selecting an imaging scheme for T1 weighted contrast. In traditional 2D sequences besides peristaltic motion, respiratory gating is the limiting factor to image the abdominal region in more depth (no of slices) and amount of T1 weighting that can be obtained. To overcome this problem we used MP-RAGE which allowed us to use very short repetition times. Figure 1a and 1b show the effects of pre and post infusion of 50 mM $MnCl_2$ with total dose 2.51 nmol/g of BW. A post infusion enhancement in signal is uniform across the pancreas where as in the case of liver, lower left lobes shows predominant enhancement. Figure 1c is the background subtracted image shows some signal saturation and an enhancement of 57 % in pancreas and 39% in liver. Figure 2 a, b, and c shows the results of a similar paradigm using a 5mM solution with a total dose of 0.2 nmol /g BW. The background subtracted image illustrates a signal enhancement of 20% in pancreas and 18% in liver. The signal enhancement is not uniform across the pancreas as at a high dose, but shows some localized hot spots at low doses. This difference is likely due to signal saturation.

Conclusion:

Abdominal images obtained using low doses of Mn result in an increase in anatomical and likely functional detail due to cell membrane mediated uptake of Mn. The previous difficulties associated with abdominal imaging in the rodent can be alleviated by the application of MPRAGE and Mn enhancement. The application of optimized levels of $MnCl_2$ should assist in the assessment of animal models in understanding abdominal diseases by taking advantage of the differences in Mn uptake associated with abdominal organs

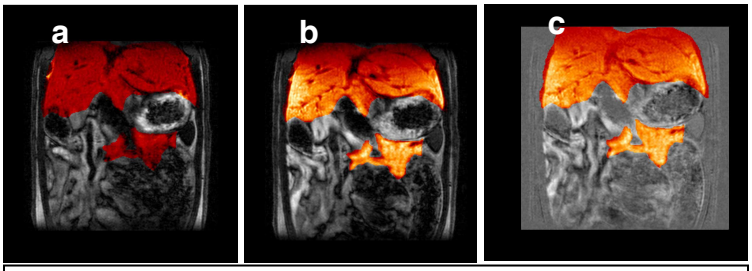

Figure 1. Highlighted region shows a portion of the rat liver and pancreas. (a) Baseline (no Mn), (b) post Mn infusion with total dose of 2.51 nmol/g of BW, (c) . Subtracted images from figure 1. (a) Basal Mn accumulation (figure 1b-1a)

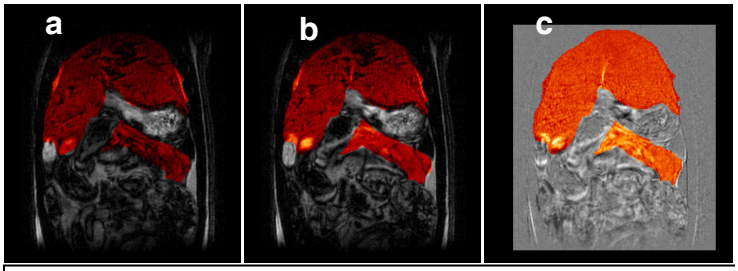

Figure 2. Highlighted region shows a portion of the rat liver and pancreas. (a) Baseline (no Mn), (b) post Mn infusion with total dose of 0.21 nmol/g of BW, (c). Subtracted images from figure 2. (a) Basal Mn accumulation (figure 2b-2a)

Reference:

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