Spin labeling perfusion MRI with simultaneous transit time measurement.

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Introduction

Perfusion imaging based on spin tagging is hampered by low sensitivty and variable label transit times encountered in human brain. The low sensitivity is partly due to the delay times required for the label to reach all tissues with different transit times, and for the slice magnetization to relax. In this work a pulsed labeling method is presented that reduces the dead time in the experiment by a) labeling outside of the imaging volume where the label (ie. the blood) is replaced quickly so that the lable can be repeated faster and b) by shifting the labeling pulse for one acquisition into the previous repition (1), and addition of a m-sequence label strategy to obtain transit time information.

Sequence

Each repetition of the sequence (Fig. 1) consists of a multi-slice EPI acquisition with low (30°) flip angle followed by a delay, and a adiabatic FOCI labeling pulse. The labeling pulse inverts a130mm slice located just under the imaging volume. During reference scans the slice thickness is reduced to 13mm while location is maintained. To reduce the slice thickness, the FOCI bandwidth was reduced, while selection gradient was kept the same . This allowed reduction of MTC effects in all slices by keeping the frequency offsets constant. Remaining MTC effects due to nonuniformity of the MT spectrum could be reduced by adjusting the offest frequency of the reference pulse. Switching betweem label and reference was controlled by an m-sequence. This allowed for a simple correlation analysis to calculate the perfusion signal as function of delay time after the label. This allows direct analysis of residual MT effects, which mostly affect the first volume, as well as transit time delays. The imaging pulses are only 30°, which results in 50% signal reduction, but leaves 87% of the label intact for the next TR.

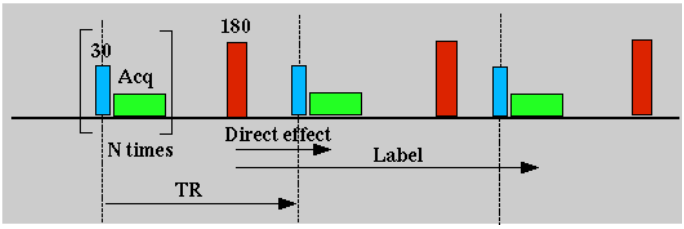

Figure 1. Schemetic labling sequence. The labeling pulse has a direct effect on the following TR and perfusion effect one TR after that. The 180 degree labeling pulse is either normal inversion or reference, depending on a m-sequence .

Methods

The design was tested on several volunteers, scanned after obtaining informed consent under IRB approved protocol on a GE 3T scanner with a 16 channel Nova head coil and home build digitizer (2,3). A number of different labeling parameters was tested, while the best setting (see below) was tested on two volunteers. Scan parameters: EPI, slice-TR 75ms, TE 32ms, overall TR 1s, delay before inversion 340ms, resolution 96x72 pixels over 220x165mm fov, 8 slices 3.5+0.5mm, 600 repetitions. A 255 bin m-sequence was used, extented to 300 bins and followed by its inverse. The data was analyzed by combining the correlation of the pixel time courses in the first and second half with the m-sequence.

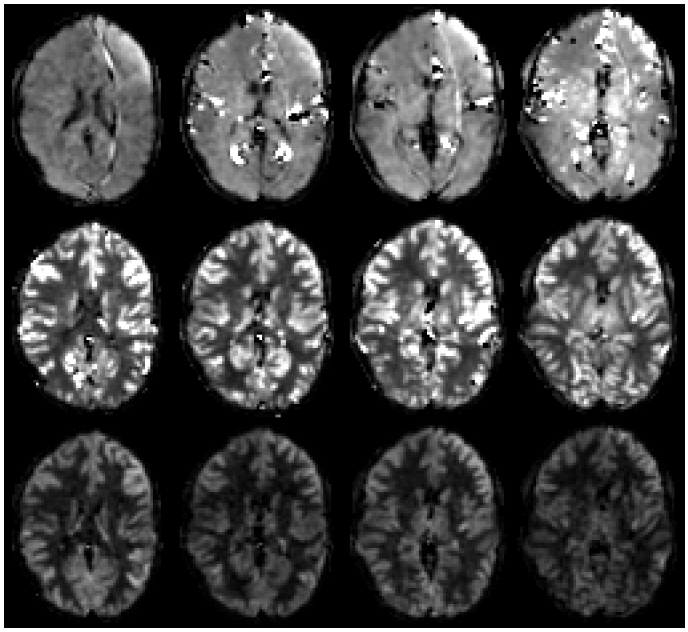

Figure 2. Example of resulting correlation maps, showing four different slices. Top to bottom are three time lags: right after inversion, and one and two seconds later.

Results & Discussion

Figure 2 shows the resulting correlation maps for four slices and three time lags. The first time lag shows the direct effects of the label on the image slices, as for this data set the reference frequency was not adjusted. The two subsequent time lags show a clear perfusion signal. The SNR of the grey matter perfusion map was 50-100, depending on location. Despite the reduced TR, the efficiency of the sequence is similar to a standard pulsed labeling technique, because of the lower acquisition flip angle. To improve the timing resolution and efficiency, a second set of imaging pulses could be added in each TR. The main advantage of the new method is the direct observation of variable transit time delays of the perfusion label and MT effects.

References 1) Wong et.al., Magn. Reson Med. **44**:511 (2000) ; 2)de Zwart et.al., 'Signal to noise and parallel Imaging perfomance of a 16-channle whole brain coil array at 3.0Tesla', Magn. Reson. Med, in press 2004; 3)Bodurka et.al., 'A scalable multi channel MRI data acquisition system', Magn. Reson. Med, in press 2004.