Prolongation of Longitudinal Relaxation During Motor Activation

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Introduction

FAIR-measurements are mostly used for stationary perfusion examinations and are based on the subtraction of images after slice-selective and nonselective inversion (1). This measurement technique can also be used in fMRI studies to examine an increase of perfusion during activation (2,3). In such applications, often a comparison of perfusion and BOLD enhancement is desired. The experiment with nonselective inversion should have minor sensitivity to flow effects and could be used for the BOLD-effect evaluation. Therefore, the signal courses in measurements with slice-selective and nonselective inversion were examined in this study.

Methods

Single-slice fMRI experiments with hand movement (60 s rest, 30 s activation) were performed at a 3 T system (Magnetom Trio, Siemens Med. Sol.). A FAIR-sequence (TR = 4 s, TE = 31 ms) based on an EPI sequence with alternating slice-selective and nonselective inversion was used. After every three activation periods, the TI was changed. The order for rest or activation (hand opening and closing once per second) was given to the volunteers by the presentation of an empty screen or a changing chess pattern, controlled by scanner signals. Activation maps were calculated for each of 11 examined TI-values. Signal intensities were evaluated within activated areas localized on the activation map of the TI = 100 ms data. For each TI value mean signal intensities were calculated for rest and activation periods and for nonselective and slice-selective inversion. The signal curves were fitted by mono-exponential T1 relaxation curves with consideration of the saturation effect due the limited TR-time. The experiment was performed with variable TI- and TR values with 6 healthy volunteers, which gave informed consent to the examination.

Results

The signal courses in a region within the left motor cortex of one volunteer study is shown for all inversion times in Fig.1. For short TI-values, three activation periods are observable. The absolute signal enhancement is diminishing with the inversion time, while an slightly increasing enhancement up to a TI-value of 1100 ms was found after normalization with the rest signal (upper signal courses). For these inversion times, the magnetization was still negative. For TI values larger than 1100 ms, the enhancement during activation is small as well in absolute as in normalized values. The fitting of T1-relaxation times was performed assuming a mono-exponential relaxation and resulted in a good fit quality. The data points for ITI = 900 ms and TI = 1100 mm were not included into the fit, since they showed effects of averaging of magnitude signals in neighbored pixels. The obtained T1-values were 1576 ms and 1620 ms during rest and activation with nonselective inversion ($\Delta T1 = 2.8$ %) and 1459 ms and 1475 ms with slice-selective inversion ($\Delta T1 = 1.1$ %). A bi-exponential fit for consideration of partial volume of brain tissue and CSF did not lead to a increased fit quality and was not possible without ambiguity about the proportion of CSF and tissue within the ROI. An increase of the fitted T1-values during activation was found in all examined volunteers.

Discussion

The effect of an increased perfusion during activation should lead to a signal increasing with the inversion time in measurements with slice-selective inversion. This is expected to result in a apparent reduction of the longitudinal relaxation (4). In our study, however, a prolonged relaxation time was found during activation for measurements with slice-selective and with non-selective inversion. Instead of a reduced T1-time in measurements with slice-selective inversion, we found only a diminished increase of T1-values compared to the results with non-selective inversion. This effect compensates the BOLD-effect in the measurements with non-selective inversion for long inversion times and might explain the results of Yongbi et al., who found a reduced BOLD-signal in a FAIR-experiment compared to results with the UNFAIR technique (2). One possible reason for the increased T1 relaxation times could be the increased blood volume during activation.

References

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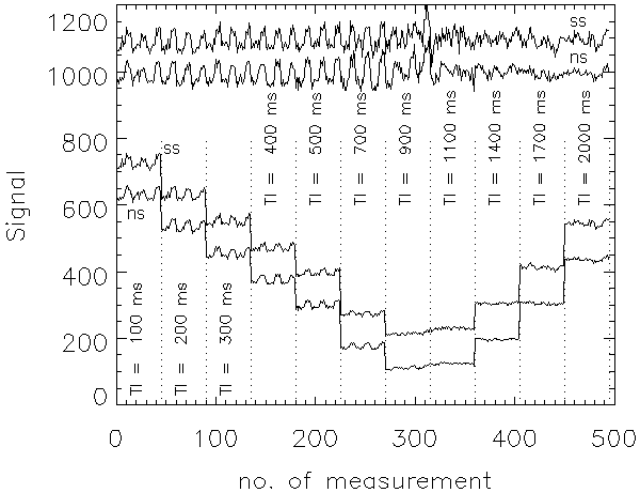

Fig. 1: Signal course in a motor cortex ROI during 11*3 rest and activation periods, measured with a single slice FAIR sequence. Evaluation was performed separately for slice-selective (ss) and non-selective (ns) inversion. The TI was changed after every 3rd activation. Measured intensities (lower curves) and values normalized to the signal during rest (upper curves) are shown.

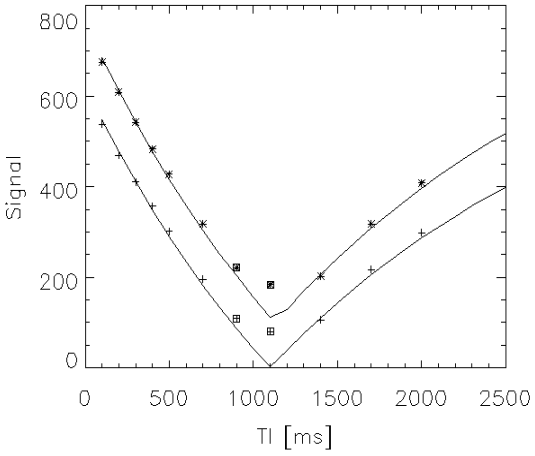

Fig.2: Mean signal intensities within the left motor cortex during rest (crosses) and activation (stars) with adjusted calculated signal course with T1-values of 1576 ms during rest and 1620 ms during activation. The measurements at TI = 900 ms and TI = 1100 ms were not included in the fitting procedure. The activation signals were shifted by 100 arb. units.