High resolution Gd-DTPA bolus tracking at 3T

P. van Gelderen[1], S. O'Flahavan[1], B. K. Lewis[2], J. A. Frank[2], J. H. Duyn[1]
[1]AMRI/LFMI/NINDS, NIH, Bethesda, MD, United States, [2]LDRR/CC, NIH, Bethesda, MD, United States

Introduction

Bolus-tracking (BT) using intra-vascular susceptibility contrast agents allows the study of cerebral hemodynamics under normal and pathologic conditions (1). After intravenous injection of Gd-DTPA, the passage of the contrast bolus through the cerebral vasculature can be monitored using rapid T2* weighted imaging. With the required scan speed of about 1 image/s, the spatial resolution of BT MRI is limited to 2-3 mm by gradient switching speed and SNR. This resolution is inferior to that of anatomical scans and results in reduced sensitivity and accuracy because of partial volume effects. In the following we have tried to improve BT resolution to 1.5mm through SENSE and the increased SNR available with and optimized 16-channel coil array (2). We demonstrate the feasibility of estimating hemodynamic parameters with high precision, even in low-perfusion areas such as (deep) white matter.

Methods

Six volunteers were scanned after providing informed consent, under and IRB approved protocol. The study was performed on a GE 3T scanner (gradient slew-rate 150T/m/s), with a 16-channel phased array coil and receiver built in collaboration with Nova Medical (2,3). A power injector (Medrad Spectris) was used to administer a bolus of Gd-DTPA contrast agent (Berlex Magnevist) through an angiocatheter in the antecubital vein. A standard clinical dose was used (0.2ml/kg) at a rate of 10ml/s. The imaging sequence was a locally developed EPI, with 144x112 voxels, 12 slices, FOV 220x171mm, slice thickness/spacing 1.5/0.5mm for a nominal resolution of 1.53x1.53x1.5mm3. With SENSE rate 2, 4us sampling rate and 50% ramp sampling the total acquisition window was 46ms. Other parameters: TE= 40 ms, TR=1 s, 180 repitions, injection start at 30s. After image reconstruction, the time series were fitted with an empirical bolus function including the 'tail' effect after passage of the bolus. Five parameters were fitted: baseline amplitude, relative bolus amplitude, arrival time, speed and relative tail amplitude. Delay and relative amplitude of the second pass were set to 24 s and 12% of first pass after initial inspection of the data. A simulation based on average gray and white matter curves with addition of 10000 noise realizations was performed to estimate the precision of the fitted parameters.

Results

The fitting procedure converged in more than 99% of the image voxels, the exception being mostly voxels in or very close to the ventricles. An example of the resulting parameter maps is given in Fig 1, showing relative bolus amplitude, the full width at half maximum (FWHM) and time to peak (TTP, arrival time + half width). The TTP showed a 4-6s contrast from cortex to deep white matter. The FWHM showed a similar contrast, but notably different in distribution. The arrival time and FWHM were not correlated. The baseline SNR and estimated precision are reported in Table 1, bases on averages over all volunteers. Note the time parameters can be estimated much more accurately than the 1s TR of the measurement.

Discussion

The results show that high resolution bolus tracking is feasible with a 16 channel coil on a 3T system, and that a standard clinical dose results is sufficient to reliably estimate rCVB and arrival time throughout all white matter. The high spatial resolution allows for more accurate estimation of flow parameters by reducing partial volume effects, while the high timing precision may facilitate detection of abnormal flow. The precision is high enough to lengthen the TR to 2s or more, which would allow imaging 24 slices.

References

1) Villringer et.al., Magn. Reson. Med. **6**:164 (1989).
2) de Zwart et.al., 'Signal to noise and parallel Imaging performance of a 16-channel whole brain coil array at 3.0 Tesla', Magn. Reson. Med, in press 2004.
3) Bodurka et.al., 'A scaleable multi-channel MRI data acquisition system', Magn. Reson. Med, in press 2004.

Table 1. SNR and precision of estimated bolus parameters.

	SNR	***basline***	***amplitude***	***time***	***speed***	***tail***
gray matter	58	0.33%	2.2%	0.08s	1.7%	0.4%
white matter	50	0.34%	4.8%	0.24s	4.9%	1.0%

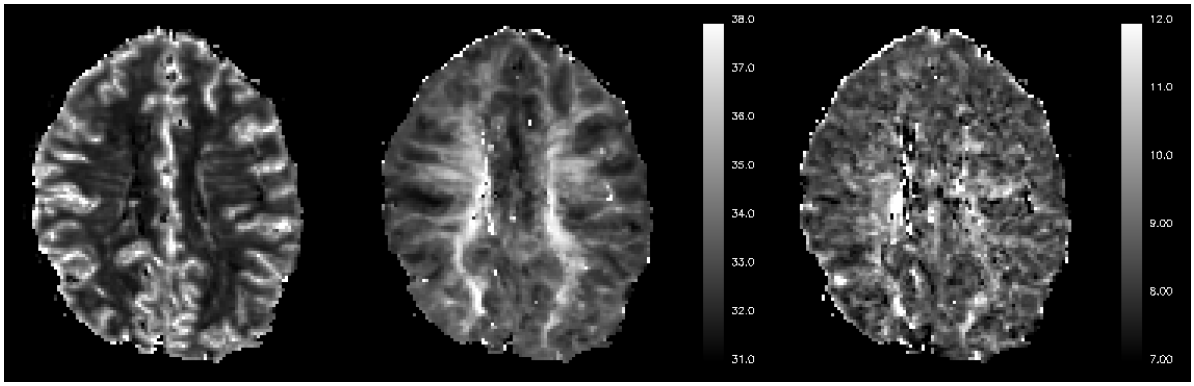

Figure 1 Fitted bolus amplitude, time to peak and width, the numbers are in seconds