High resolution MR vessel size imaging using dual contrast agent injections

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Introduction

Microvascular dimensions can be estimated by vessel size imaging (VSI) based on R_2^* and R_2 measurements following bolus injection of contrast agents (1, 2). The vessel caliber can be calculated using measured parameters including ΔR_2^*, ΔR_2, cerebral blood volume (CBV) and apparent diffusion coefficient (ADC). This method has been successfully applied in humans using a double-echo sequence (3). However, such sequence is not widely available in clinical scanners and may be limited in the spatial resolution. This study proposed using two separate contrast agent injections to acquire VSI map with higher spatial resolution in humans. Computer simulation was conducted to assess the possible errors that may be resulted from different delays between the two image sampling to the contrast injections.

Methods

VSI was performed in eight patients with brain tumors on a 3 Tesla clinical scanner (GE Signa EXCITE, Milwaukee, WI, USA). Two doses of 0.2 c.c Gd-DTPA (Magnevist) /kg body weight were injected separately, with the first one for ΔR_2^* and the second for ΔR_2 measurements, at 4 c.c/s using a power injector. The ΔR_2^* imaging was performed using a single-shot GE-EPI (TE=35ms, TR=1500ms, FA=90) and the ΔR_2 using a single-shot SE-EPI (TE=70ms, TR=1500ms). The two sets of imaging were separated by a 10-min waiting time, and the other imaging parameters were slice thickness = 4 mm, whole-brain coverage, 60 phases, acquisition matrix = 128×128 (2 patients, with parallel imaging, R = 2) or 64×64 (6 patients). CBV maps were calculated from the GE-EPI scan. Before the bolus injection, ADC maps were acquired using a set of single-shot SE-EPI with b =1000s/mm^2. In addition, a pre-dose of 0.1 cc/kg Gd-DTPA was administered five-min before the first dynamic scan to reduce the T1 effects in case of contrast leakage. The vessel caliber was calculated using the equation R=0.867*(CBV*ADC)^1/2*$\Delta R_2^*/\Delta R_2^{3/2}$, in which the $\Delta R_2^*/\Delta R_2^{3/2}$ ratio was obtained by fitting the temporally aligned R_2^* and R_2 measurements (3). A computer simulation was conducted to assess the percent errors associated with the temporal mis-alignment due to varied time delays between the image sampling and the contrast injection, which was assumed to be within one TR.

Results

The vessel calibers of three normal tissue ROIs, occipital gray matter (OC), thalamus and deep white matter (WM), obtained from the high resolution scans in two patients were listed with the mean values from the low resolution scans in the table. The values from high and low resolution scans were comparable and both agreed well with those presented in previous literatures (3). The results proved the feasibility of this high resolution protocol. Figure 1 demonstrated the percent error caused by simulated delay time differences between the dual contrast scans . The largest errors increased as the delay time difference, with overall errors less than 8% when the delay time difference was within +/- 1.5 s (one TR in our case). Figure 2 showed vessel diameters maps with higher spatial resolution from the two patients scanned at 128x128 matrix, than that from one of the patients at 64x64.

Table-Vessel size in three ROIs with 128×128 and 64×64

	OC	Thalamus	WM
Patient-1	36.8 mm	25.0 mm	19.2 mm
Patient-2	33.7 mm	25.6 mm	17.2 mm
Mean value in 64×64	35.4±13.5 mm	21.5±8.5 mm	15.4±5.1 mm

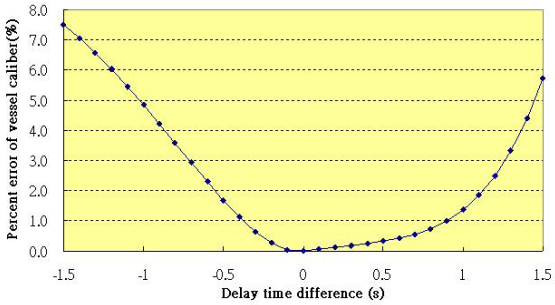

Figure-1 Computer simulation of the vessel diameter (R) errors with the assumed R=10 micrometer.

Discussion

Using existing sequences in clinical scanners, our study showed that VSI could be obtained with two separate dynamic contrast scans. Comparing with using the dual echo sequence, this approach is able to result in vessel diameter maps with higher spatial resolution. Possible effects from the first injection to the second were not observed in the results. Potential errors caused by temporal misalignment between two dynamic contrast scans were found within acceptable range based on computer simulation. Further verification study is required by investigating the clinical implications of the VSI maps obtained from this method.

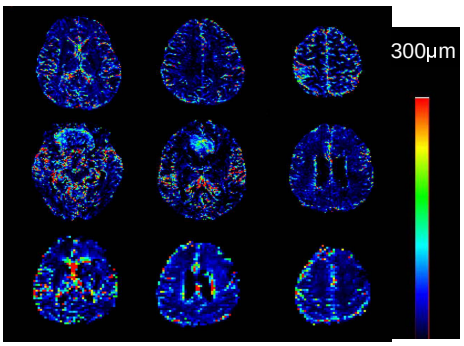

Figure-2 VSI maps in 3 patients (from top to bottom). Patient-1and Patient-2 datasets were obtained with matrix size 128×128, whereas the Patient-3 with 64×64.

References

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