Snap-Shot ASL

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Introduction

We have previously demonstrated that single shot 3D GRASE using continuous ASL (CASL) at 3T generates perfusion images comparable to those obtained with a 2D EPI readout (1). Recently, the performance of the sequence has been further improved by implementing a more efficient pseudo-continuous ASL (pCASL) approach for flow driven adiabatic inversion, compatible with body coil transmission and array receiver, and by adding background suppression (BS) pulses (2). The improved sequence has an approximate 6-fold sensitivity increase with respect to CASL EPI at 3T (3). This improved sensitivity permits a significant reduction in scan time, making possible to obtain perfusion maps in less than 1 min.

Materials and Methods

Studies were performed on a 3T Siemens Trio scanner using the product 8-channel head receiver array. Four healthy volunteers and three acute stroke patients were scanned using the pCASL BS 3D GRASE sequence (shown in Fig. 1). Imaging parameters were: resolution = 3.9 x 3.9 x 6 mm^3, FOV = 250 x 218 x 96 mm^3, 16 nominal partitions with 13% oversampling, 5/8 partial Fourier, measured partitions = 11, matrix size = 64 x 56, BW = 3004 Hz/pixel, gradient-echo spacing = 0.4 msec (with ramp sampling), spin-echo spacing = 26 msec, total read-out time = 290 msec, effective TE = 43msec, refocusing flip angle = 180° and TR = 3.5 sec. The pCASL pulse (4) consisted of 1280 selective RF pulses, played sequentially, at equal spacing, for a 1.2sec labeling duration. Each RF pulse was shaped as a Hanning window (peak B_1=53mG, duration=500 μsec and G=0.6 G/cm). For the control pulse, the RF phase alternated from 0 to 180°. The post-labeling delay was 400msec. Two hyperbolic secant inversion pulses (15.35 msec duration and 220 mG RF amplitude) were added with inversion times of 1590msec and 380msec before the image acquisition, respectively, for background suppression (BS). The first pulse was applied selectively to the imaging slab while the second pulse was non-selective. The pCASL pulse was placed in between the two BS pulses. Bipolar gradients (b=5sec/mm^2) were added between the excitation and the first refocusing pulse of the GRASE readout to suppress intravascular signal. 96 perfusion images were obtained by subtraction of tag and control (after discarding 4 dummy scans). Perfusion maps were generated by averaging the individual perfusion images. The number of averages was increased from 1 to 9. Mean whole brain perfusion was measured as a function of number of averages in 10 different perfusion maps and the coefficient of variation (CV=standard deviation/mean) of the measurement was computed. Then the perfusion maps obtained from 6 averages were used to characterize the lesion in the stroke patients, by measuring the perfusion signal in the stroke region as a fraction of the perfusion signal in the healthy hemisphere (comparable ROI).

Results and Discussion

The standard deviation of the mean whole brain perfusion signal decreased as the inverse of the square root of the number of averages as expected (Fig. 2a), since it has been previously shown that perfusion data do not have any substantial temporal autocorrelation (5). The same trend was observed for the CV (Fig. 2b), which in normal volunteers was reduced to 6.5% by averaging 6 perfusion images (42 sec of scan time). In the stroke patients, perfusion maps generated with 6 averages showed clearly the stroke area (Fig. 3b) and the fractional perfusion signal in the stroke region measured in these maps was very close to that measured in the map obtained using all the acquired data (Table 1).

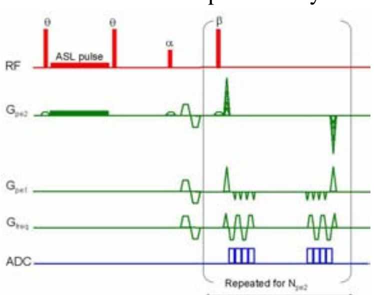

Figure 1: Pulse sequence diagram, showing the background suppression (θ) and p-CASL pulses, added to the single shot 3D GRASE readout.

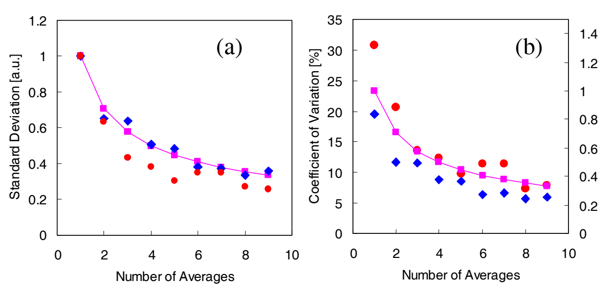

Figure 2: Mean whole brain perfusion signal as a function of the number of averages: (a) standard deviation normalized by the first point; (b) coefficient of variation.

—■— 1/√N. of averages ◆ normals (4) ● stroke patients (3)

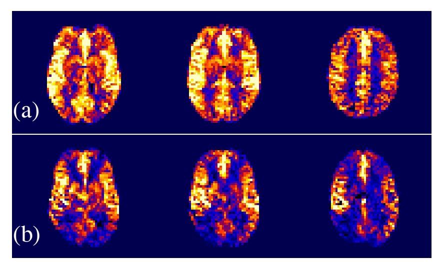

Figure 3: Perfusion maps obtained by averaging 6 perfusion images: (a) normal volunteer; (b) stroke patient 3.

Patient number	1	2	3
	60F	87M	49F
Stroke	Left MCA	Left MCA	Bilateral MCA
Hours after stroke onset	34	16	36
Fractional perfusion (96 averages map) %	0.3	45.1	28.0
Fractional perfusion (6 averages maps) %	0.1 ± 1.5	45.3 ± 4.3	27.0 ± 3.3

Table 1: Perfusion measurements in the stroke patients. The perfusion signal was measured in a ROI covering the stroke area and expressed as a % of the signal in a comparable ROI in the healthy hemisphere.

Conclusions

Snap-shot ASL perfusion was made possible by using a pCASL BS 3D GRASE technique that allowed acquisition of perfusion maps in less than 1 minute with enough resolution and SNR to characterize the lesion in stroke patients. The ability to accurately define ischemic lesions in less than a minute should greatly facilitate perfusion imaging in poorly cooperative patients or potentially for dynamic perfusion imaging during interventions.

Bibliography: 1. Fernández-Seara *et al., Mag Reson Med,* 54:1241-7 (2005). 2. Fernández-Seara *et al., Human Brain Mapping*, In Press. 3. Wang *et al., Radiology,* 235:218-228 (2005). 4. Garcia *et al., ISMRM* 2005, p 37. 5. Aguirre *et al., Neuroimage* 15:488-500 (2002).

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