Reproducibility of Total Cerebral Blood Flow and Determination of Tagging Efficiency in pCASL using Gated and Non-Gated PCMRA

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Introduction:
Pseudo-Continuous Arterial Spin Labeling (pCASL) is a promising technique for investigating vascular and tumoral pathologies because it can provide the sensitivity of the continuous arterial spin labeling method while overcoming many of its limitations (1- 4). However, the accuracy of quantitative cerebral blood flow (CBF) measurement using pCASL depends on the tagging efficiency . The tagging efficiency depends on the subject and magnetic field (both static and radio frequency) homogeneity. It is, therefore important to determine the tagging efficiency for each subject. Phase contrast MRA can be used for determining the tagging efficiency (2). PCMRA data is generally acquired with gating. However, gating involves longer scan times. The objective of this study is to compare quantitative CBF values obtained with and without gated PCMRA and determine its reproducibility.

Methods and Materials:
Seven healthy volunteers were recruited for this study. MRI scans were performed on a 3 T Philips scanner using an 8-channel phased array head coil. A balanced pCASL sequence was used in this study with the following scan parameters: single-shot GE-EPI, with FOV=240 mmx240 mm, matrix=80x80, 3mm x 3mm in plane resolution, 5 mm slice thickness with no gap, 29 slices, labeling duration 1650ms, post labeling delay 1525 ms, pulse repetition time 4500 ms, echo time 14 ms, SENSE factor 2.0, and number of dynamics 40. Three dimensional time of flight MRA was acquired using the 3D fast field echo (FFE) sequence for visualizing the internal carotid and vertebral arteries for positioning the labeling plane for pCASL and PCMRA using the following scan parameters: TR/TE = 14 ms /2.4 ms, flip angle = 16^0 , slice thickness of 2 mm, and SENSE factor of 1. We acquired gated and non-gated PCMRA using the 2D FFE sequence to estimate the whole brain average blood flow using the following scan parameters: TR/TE = 11 ms/6.7 ms, flip angle = 15^0, single 7 mm slice. The time for gated and non-gated PCMRA techniques is 3.8 and 1 minutes, respectively.

The reproducibility of CBF measurements was investigated by scanning seven subjects twice. Following the completion of the first scan, the subjects were taken out of the scanner and after a 10 to 20 min break they were repositioned in the magnet and scanned again.

The total CBF using PCMRA was obtained with the pulsatility-based segmentation (PUBS) method (5). Automatic segmentation of atrial vessels was implemented. In pCASL, the CBF maps were calculated using the published method (2). The tagging efficiency was calculated based on the following assumption: in the brain, total CBF obtained from pCASL should be equal to the sum of flows from the left/right internal carotid arteries (ICA), and left/right vertebral arteries (VA). Student t-test was used to compare the reproducibility of the total CBF values obtained from gated and non-gated PCMRA techniques. $P<0.05$ was considered to be significant.

Results:
Fig.1. shows the PCMRA technique to obtain the total CBF. One slice was placed close to the C2 location with its orientation perpendicular to the ICA and VA. Magnitude and phase images are shown in Fig. 1. (b) and (c). Automatically segmented left and right ICAs and VAs are shown in Fig. 1. (d). The total CBF obtained from PCMRA was evaluated for the gated and non-gated reproducibility at the same position and scan-to-scan reproducibility by analyzing data acquired twice after reposition. There was no significant difference in CBF between gated and non-gated techniques (Fig. 2a). This figure also shows excellent scan-to-scan reproducibility.). The tagging efficiency for each subject is shown in Fig 2(b) and significant inter-subject variability can be seen.

Discussion and Conclusion:
In pCASL, the tagging efficiency strongly depends on the subject and other factors. It is necessary to develop a reliable technique with a short scanning time to determine the tagging efficiency. We investigated the reproducibility of the total CBF quantification and the effect of gating in normal subjects twice within one hour. Based on the student t-test, no statistically significant differences between the mean of the two measurements was observed, suggesting excellent reproducibility. Also, this study demonstrates that non-gated PCMRA, which involves shorter scan times, is a reliable method for measuring the tagging efficiency.
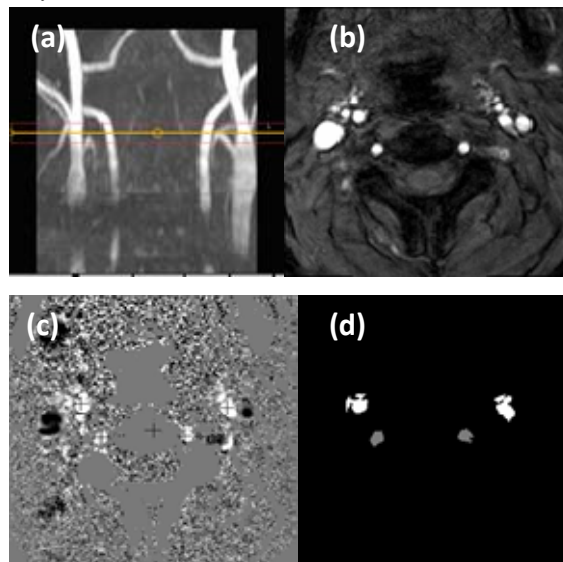

Fig.1. Total CBF measurements with PCMRA, (a) slice position, (b) magnitude image, (c) phase image, (d) automatically segmented left and right ICAs and VAs.
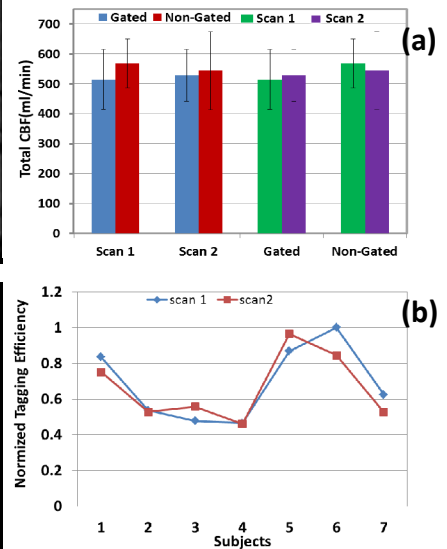

Fig. 2. (a) Reproducibility of total CBF measurements with gated and non-gated techniques and between scans. (b)Tagging efficiency among the subjects.

Reference
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