PASL Filtering: A Method of Improving Clinical Perfusion Imaging

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Introduction: Arterial spin labeled (ASL) MR imaging is a powerful method for quantitatively measuring cerebral perfusion [1-3]. We have implemented ASL as a routine part of the clinical MR evaluation of the brain, acquiring 3500 cases over a 10-month period. In a small, but significant number of these cases, the data is uninterpretable due to excessive patient motion and system instability. We have implemented a filtering technique to significantly improve the quality and usability of the quantitative perfusion map.

Data Acquisition: Cerebral blood flow (CBF) was measured with QUantitative Imaging of Perfusion using a Single Subtraction with Thin Slice TI1 Periodic Saturation (QUIPSS II TIPS a.k.a. Q2TIPS) [4] with Flow-sensitive Alternating Inversion Recovery (FAIR) [5] acquiring 120 control/label pairs over 6.5 minutes. The label images were then subtracted from the control images and averaged together to produce the perfusion-weighted images, which were then scaled and converted to quantitative CBF maps.

PASL Filtering: The PASL filter consists of two parts: the mean filter and the standard deviation (SD) filter. The mean and the standard deviation of the tissue intensities were computed for each perfusion weighted subtraction image. Images with a mean value of 2.5 standard deviations from the average mean values or a SD value that is 1.5 standard deviations larger than the average SD values were considered outliers. These subtraction images were excluded from calculating the CBF maps. Additionally, no filtering occurred when the natural log of the difference between maximum and minimum SD values in the entire dataset was less than 1. This constraint effectively eliminated the possibility of overfiltering. These thresholds were determined through empirical performance of the filter.

The filtering procedure was performed on both a volume-by-volume basis and a slice-by-slice basis. This allowed the removal of entire volumes or just a few slices of corrupted data. The union of the two filtering procedures generated the set of subtraction images that were discarded when calculating the quantitative perfusion map.

Results: Figure 1 is an example of an uninterpretable case due to patient motion (top row). The PASL filter effectively restores the perfusion signal (bottom row). By throwing out 1 control/label pair out of 120, the perfusion image was completely restored. The PASL filter can also remove edge artifacts caused by mis-registration between the control/label pairs (Figure 2). This mis-registration occurred despite the fact that the control and label images were realigned with SPM before they were subtracted. By discarding 5 of the 120 control/label pairs the edge artifacts were greatly reduced.

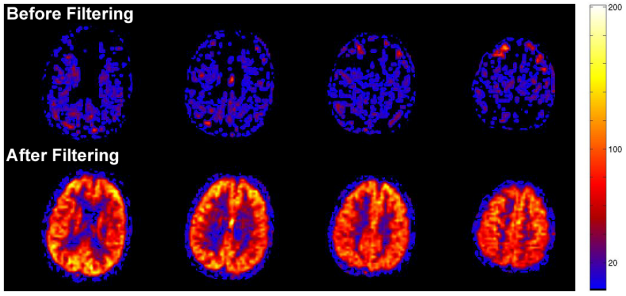

Figure 1. CBF maps before and after PASL filtering.

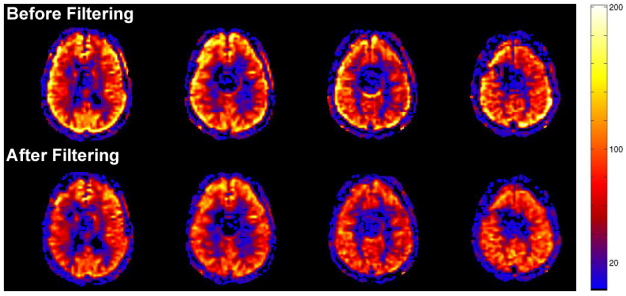

Figure 2. Reduced edge artifacts after PASL filtering

Discussion: The purpose of this work was to improve the quality and stability of the absolute quantitative perfusion maps in a clinical setting. Perfusion imaging requires signal averaging to improve SNR. Ideally, the signal contained in each control/label pair should be identical and the SNR should increase by the square root of the number of control/label pairs. Our experience using ASL clinically is that occasionally a few of the control/label pairs will be corrupted. By detecting and discarding these outliers we have improved the quality of our perfusion imaging. This technique has proven to be very successful, often recovering useful perfusion images from previously uninterpretable image data. In a busy clinical practice like ours in which PASL has been performed in over 3500 cases during 2007, such an improvement has had a positive impact on the clinical interpretation of brain MR studies.

Acknowledgements and References: Research support was provided by NIBIB and the Human Brain Project through grants R01EB004673 and EB004673-02S2. **(1)** Buxton, RB, et al., MRM, 1998. 40(3):383 (**2)** Calamante, F, et al.,J Cereb Blood Flow Metab, 1999. 19(7):701. **(3)** Edelman, RR, et al., Radiology, 1994. 192(2): 513. **(4)** Luh, WM, et al., MRM 1999. 41(6): 1246. **(5)** Kim, SG and Tsekos NV, MRM 1997. 37(3): 425.