

# Comparison Between Total CBF Values Measured by ASL and Phase Contrast Over Increased Range of CBF Values

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## Introduction

Arterial spin labeling (ASL) utilizes the water in arterial blood as endogenous contrast agent to assess cerebral blood perfusion and therefore is becoming more commonly used. A perfusion image is generated by subtracting a tagged image from a control image, where the tagged image is acquired following the “labeling” of the blood upstream using an inversion pulse. The time delay between the labeling and the image acquisition, which is the transient time, allows the labeled blood to reach the imaging volume. While ASL is sensitive to changes in cerebral blood flow (CBF), derived absolute CBF values are influenced, among others, by the choice of the transient time and by the actual blood flow velocities. This project aims to compare between measurements of total CBF obtained with ASL and phase contrast MRI (PCMRI). The comparison was done over a wide range of CBF values by manipulating the end tidal pCO<sub>2</sub> level following the application of continuous positive airways pressure (CPAP).

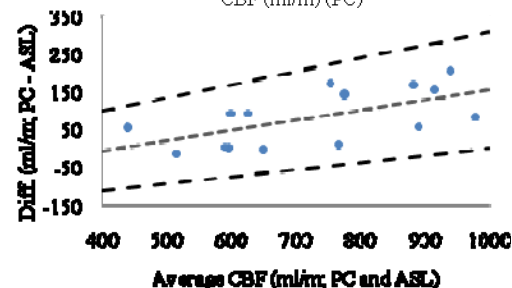
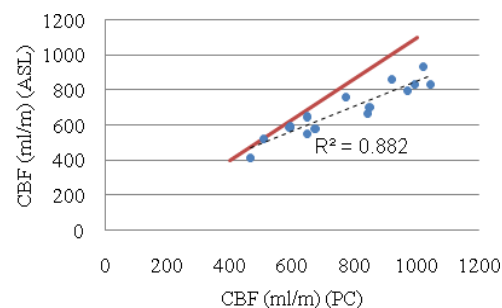
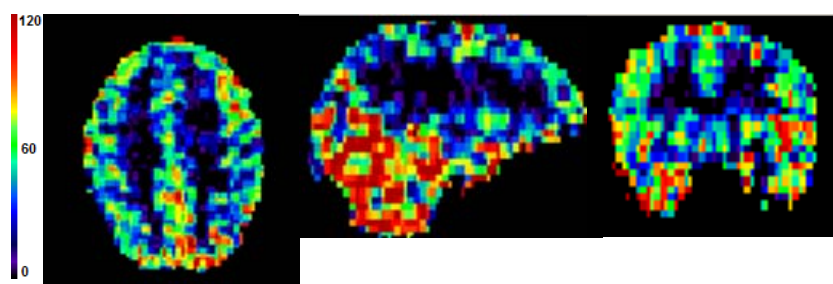
## Methods

Five healthy subjects (2M:3F, ages 24 to 39 years) underwent MRI scans using 3T (Verio, Siemens Healthcare), which included whole brain ASL and cine phase contrast repeated at 3 physiological states, rest, moderate (up to 6mmHg) and high (12 mmHg) continuous positive airway pressure. End tidal pCO<sub>2</sub> level ranged from 45 to 20 mmHg. CBF in a normal subject is reduced by approximately 3% per mmHg. Total cerebral blood flow (tCBF) from PCMR was obtained by summation of the arterial inflow through the two internal carotids and vertebral arteries [1]. The PCMRI imaging parameters were FOV of 14x14 cm, slice thickness of 6 mm, matrix of 256x192, flip angle of 20 degrees, minimum TR/TE of 10/4ms, and VENC of 70 cm/sec.

Total cerebral blood flow from ASL was obtained by summation of the relative CBF values over the entire brain volume. A brain volume mask was obtained using the high resolution (HR) 3D T1-weighted MPRAGE data set which was then registered with the ASL volume. The masking of the non brain regions was obtained using the FSL-BET (Brain Extraction Tool) [2]. Registration of the HR T1W and ASL volumes was obtained through a rigid body transformation using FSL-FLIRT [3]. The ASL imaging parameters were FOV of 22x22 cm, slice thickness of 3 mm, acquisition matrix of 80x80, flip angle of 90 degrees, TR/TE 2500/11ms, T1/T2 1500/600 ms, and 105 measurements resulting in total scan time of 5min. The correspondence between the ASL and the PC based tCBF values was determined by plotting the relationship between the two and also by using a linear regression based Bland Altman plot of the differences vs. the average values [4,5].

## Results

Fig. 1 demonstrates the relative CBF values obtained with the ASL over the whole brain (axial, sagittal and coronal views are shown). The application of CPAP resulted with an increased range of tCBF values, from about 980 mL/min at rest to about 400 mL/min at the high CPAP state. Fig. 2 demonstrates the relationship between the PC and the ASL based tCBF values for the 3 states of CO<sub>2</sub> levels. A strong linear correlation with R value of 0.94 was found. However the trend line (dashed line) had a slope of 0.72, considerably smaller than the line of equality (red line). The Bland Altman regression trend and the 95% limits of agreement for the difference in tCBF values are shown in Fig. 3. This plot demonstrates an increasing difference between the two measurements with increased tCBF values. In addition, the 95% limits of agreement are -113.9 to 99.0 mL/min at 400 mL/min and 1.1 to 309.0 mL/min at 1000 mL/min.



## Conclusion

Total CBF values obtained with PCMRI and ASL are strongly linearly correlated. However, ASL tends to underestimate tCBF compared with PC derived values. This underestimation increases with increased blood flow velocities. Consequently, adjustment of the transient time based on the subject's tCBF may be needed to obtain reliable absolute CBF values with ASL. In summary, PCMRI based measurement of tCBF could be used to either guide the choice of the transient time interval and/or for “calibration” of the ASL derived relative CBF values.

## References

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Top: tCBF values measures with PC and ASL, with trend-line (dashed) and line of equality (bold).  
Bottom: Regression based 95% limits of agreement for difference in tCBF measurements by PC and ASL.