qCBF: A Comparison of the Accuracy Between the Bookend Technique, Empirical Reference Values and $[O^{15}]$-H_20 PET in Moyamoya Patients

V. Parikh[1], J. Lee[2], W. Shin[3], J. Mouannes[1], A. Snyder[2], C. Derdeyn[2,4], and T. Carroll[1,5]

[1]Biomedical Engineering, Northwestern University, Evanston, Illinois, United States, [2]Radiology, Washington University, St. Louis, Missouri, United States, [3]National Institute of Health, Baltimore, Maryland, United States, [4]Neurology, Washington University, St. Louis, Missouri, United States, [5]Radiology, Northwestern University, Chicago, Illinois, United States

INTRODUCTION:

Quantitative and accurate cerebral blood flow (CBF) MR-based measurements would have a tremendous impact on the study of normal human physiology and abnormal cerebrovascular pathophysiology, including conditions such as stroke. Using dynamic susceptibility contrast (DSC) MRI, the "Bookend" technique [1, 2] can produce reliable and reproducible CBF measurements using post-gadolinuium T_1 and T_2* changes in the cerebral blood pool and white matter [3]. An alternative approach to the quantification of CBF is to rescale normal appearing white matter to a population-based reference value of 22 ml/100g/min [4]. A direct comparison between the Bookend Technique and quantification based on rescaling to an empirical reference value has to date not been attempted. Our goal was to compare the accuracy of CBF measurements obtained by the "Bookend" Technique and CBF values rescaled to 22mL/100g/min for white matter with those obtained using $[^{15}O]$-H2O positron emission tomography (PET) in patients with angiographically confirmed cerebrovascular disease.

MATERIALS AND METHODS:

Seven patients with confirmed Moyamoya disease were enrolled from an on going clinical trial at the Mallinckrodt Institute of Radiology at the Washington University School of Medicine. MR and PET images were obtained from these patients and were co-registered using custom-written for region of interest analysis. PET CBF maps were generated by using the autoradiographic method [5]. MR imaging CBF maps were calculated using the "Bookend" technique [1, 2] and blurred with a 10mm Gaussian convolution kernel to match the spatial resolution of the PET images. Large ROIs were draw in regions of white matter (WM) above the ventricles and grey matter (GM) in the cortical ribbon on the MR CBF images and then correlated with the same region on the PET images. Initially, we compared the original "Bookend" measurements and then rescaled the qCBF values by assigning a mean qCBF value for normal appearing white matter of 22 mL/100g/min [4].

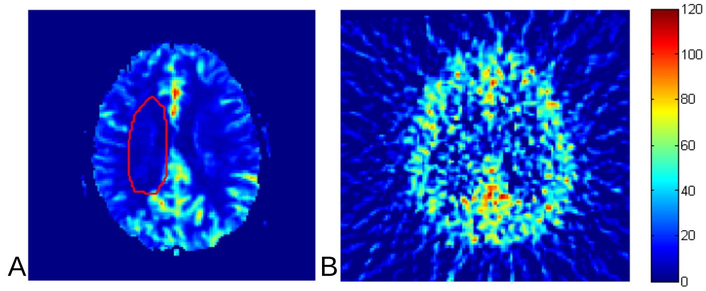

Figure 1. A and B are representative CBF images for a brain slice from MR and PET respectively .MR image shows a representative WM ROI.

RESULTS:

We performed a regression analysis of the original "Bookend" CBF versus PET CBF and scaled MR CBF values versus PET CBF. Figure 1 (A, B) shows the comparison between the representative CBF images.

Figure 2 (A,B) shows the results of the MR CBF and PET CBF correlation analysis for both the original and scaled MR CBF values. For the "Bookends", slope = 0.98 and offset = -7.5 with Pearson's r = 0.74 and p $<10^{-3}$. For scaled values, slope = 1.4 and offset = -12 with r = 0.94 and p$<10^{-3}$. Figure 2(C, D) shows the Bland-Altman analysis. For original "Bookend" measurements, PET CBF values are systematically higher. For scaled MR measurements, PET is higher at low flow and lower at high flow.

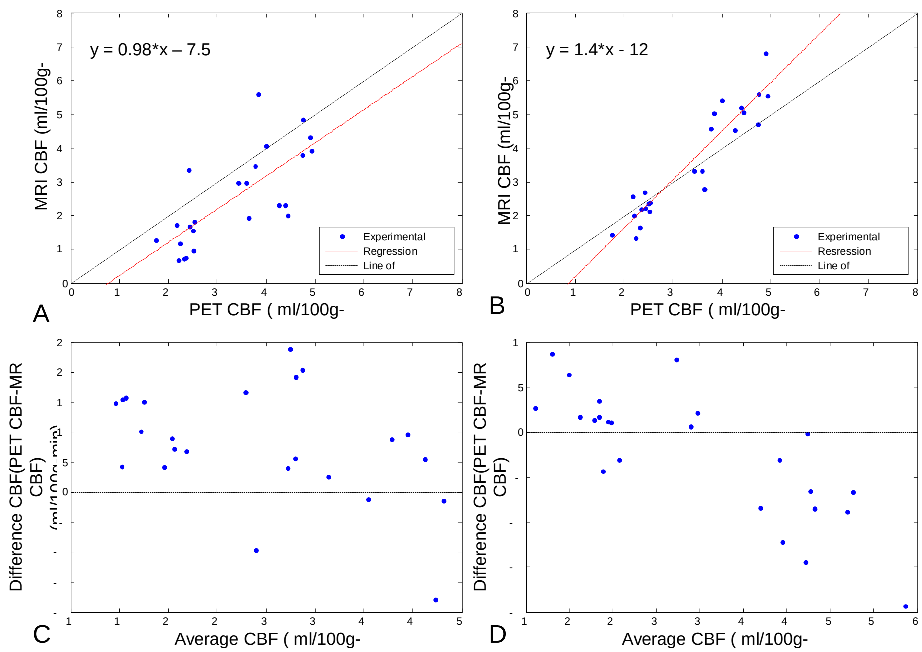

Figure 2. A and B are correlation plots of "Bookend" MR CBF and scaled [4] CBF versus PET CBF, respectively. C and D are Bland-Altman Plots of the "Bookend" MR CBF and scaled CBF versus PET CBF, respectively.

CONCLUSIONS:

Our regression analysis shows that the "Bookend" technique gives a fit with slope that is closer to the desired line of unity. The assumption of that white matter blood flow is a constant at 22/ml/100g/min is not consistent with ROI WM measurements of quantitative "Bookends" CBF nor PET CBF. Discrepancies between "Bookends" CBF and PET CBF may be related to differences in tracer kinetic models and the semi-diffusible nature of radio-labeled water.

REFERENCES: [1] K.E. Sakaie, et al. JMRI 21: 512-519 (2005) [2]W.Shin, et al. MRM 56:138-145 (2006) [3] W. Shin, et al. MRM 58(6): 1232-41 (2007) [4] L. Ostergaard, et al. MRM 36: 726-736 (1996) [5] Videen, et al. JCBFM, 7:513-516 (1987)