Comparing Blood Flow between Brain Hemispheres

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Introduction: A common assumption when imaging the cerebrovascular system is to assume that cerebral blood flow (CBF) is symmetric. This assumption is often made when comparing contralateral hemispheres of the brain in diseases such a stroke [1,2]. A recent finding [4] demonstrated asymmetry in the blood flow between left/right paired vessels feeding the brain. In the middle cerebral artery (MCA), for example, higher flow was found on the left side in 27/30 healthy subjects. In the posterior cerebral artery (PCA) higher flow was found on the right side in 19/30 subjects. In this study we further explore the question: "Is it okay to assume blood flow is the same on both sides of the brain?" Phase contrast (PC) and arterial spin labelling (ASL) methods are used to answer this question in normal subjects.

Methods: Twenty-three healthy subjects (12 males and 11 females) were imaged with a 3 T MR scanner (Discover 750, GE Healthcare). PC imaging was used to measure flow velocity in major arteries and ASL was used to estimate tissue perfusion. Flow in five intra-cranial arteries and corresponding perfusion territories of the brain were examined. Cut-planes were placed through the PC data on the left and right MCA-M1, PCA and the anterior cerebral artery (ACA) segments to calculate the volume flow rate (VFR). Regions of interest were placed in grey matter of the corresponding vascular territories and mean tissue perfusion was measured (Fig 1). Mean and standard deviation of the VFR and perfusion measurements were calculated. Laterality index (LI) was calculated and compared in the MCA and PCA vessels/territories. ANOVA tests were used to assess significance of any flow asymmetry.

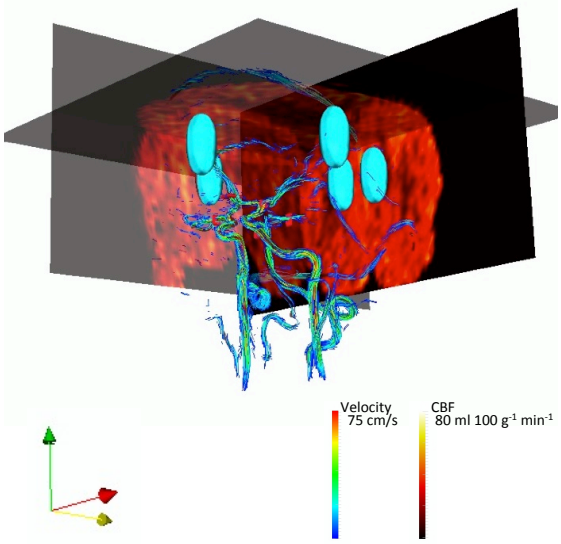

Figure 1: Example of measurement locations. Cut-planes are shown in red and ROI measurements are the blue ellipsoids.

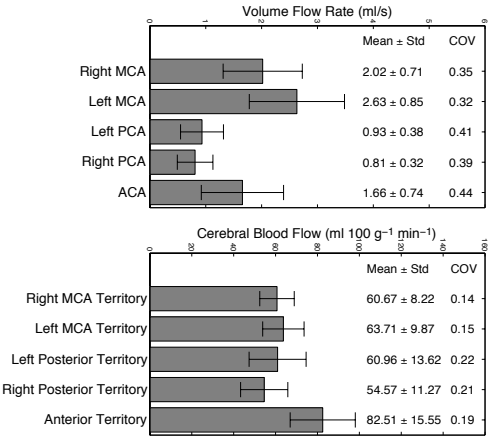

Figure 2: Group mean and standard deviation measurements. Error bars represent one standard deviation

Results: Fig 2 summarizes the average VFR and CBF measurements over the subjects. The coefficient of variation was more than 1.9× higher in the PC-based VFR measurements. In the MCA territory, flow was higher in the left hemisphere. The PCA territory had higher flow in the right hemisphere (Table 1). Tissue perfusion had less CBF asymmetry by ASL than VFR asymmetry by PC MR.

Discussion: Average LIs between 2% and 13% were observed, suggesting that an expected difference of greater than 4% to 26% should be expected when testing for differences between hemispheres. A similar caution should be applied when cross-calibrating flow measures. The reduction in asymmetry in perfusion is possibly due to additional myogenic control over small vessel flow and the presence of collateral flow pathways.

References:
1. Dahl, *Stroke*, 1994.
2. Tan, *Neurology*, 2007.
3. Kosior, *JMRI*, 2007.
4. MacDonald, *Proc ISMRM*, 2014.

Table 1: Asymmetry between the right and left sides of the brain in the MCA and PCA vessel and territories. Laterality index is defined as LI = (L-R)/(L+R) where L and R are the left and right measures.

	VFR			CBF		
Vascular Territory	Mean Difference (ml/s)	Laterality Index, %	ANOVA	Mean Difference (ml 100 g^{-1} min^{-1})	Laterality Index, %	ANOVA
MCA	0.61	13	p = **0.013**	3.04	2	p = 0.447
PCA	-0.12	-7	p = 0.252	-6.39	-6	p < **0.001**