The Precision of ASL in Measuring Cerebrovascular Reactivity in Cardiovascular disease patients.

U. C. Anazodo[1,2], N. Suskin[3], J. Wang[4], J. K. Shoemaker[5], and K. St Lawrence[1,2]

[1]Lawson Health Research Institute, St Joseph's Health Care, London, Ontario, Canada, [2]Department of Medical Biophysics, University of Western Ontario, London, Ontario, Canada, [3]London Health Science Cardiology Rehabilitation Program, London, Ontario, Canada, [4]Department of Neurology, UCLA, Almanson-Lovelace Brain Mapping Center, Los Angeles, California, United States, [5]Neurovascular Research Laboratory, School of Kinesiology, University of Western Ontario, London, Ontario, Canada

Introduction The prevalence of cardiovascular disease (CVD) and dementia increase with age, and these diseases share common risk factors including hypertension, diabetes and high blood cholesterol, suggesting a link between cardiac dysfunction and cerebrovascular health. An established method of assessing cerebrovascular health is to measure the response of cerebral blood flow (CBF) to a change in arterial CO_2 tension – i.e., cerebrovascular reactivity (CVR) – since increased vascular resistance will diminish CVR. Arterial spin labelling (ASL) can be used to map regional CVR[1,2], and has been used to demonstrate CVR reductions associated with Type-2 diabetes[3]. Our objectives are to use ASL to measure CVR in patients with heart disease and to evaluate the effects of cardiovascular rehabilitation (aerobic fitness) on cerebrovascular tone. The purpose of this initial study was to investigate the reproducibility of CVR measurements acquired using a pseudo-continuous ASL (pCASL) technique in CVD patients.

Materials and Methods Ten CVD patients (age 58 ± 8 years) were scanned on a Siemens 3.0T Verio system using a 32-channel array coil. pCASL images were acquired with a labelling duration of 1.5s consisting of 1600 Hanning pulses (duration of 500 μs)[4] and a post label delay of 1.0s. Acquisition parameters were; FOV=24cm, matrix=64x64, bandwidth =2.3kHz/pixel, TR/TE =3500ms/12ms, and 12 axial slices (6 mm thickness, 2 mm gap). Patients breathed room air for 5 min, followed by 5 min of inhaling a mixture of $CO_2/O_2/N_2$ (6:21:74%). The CO_2/air mixture was delivered by a facemask attached to a large reservoir bag, and end-tidal CO_2 ($P_{ET}CO_2$) was monitored continuously. Each patient repeated the protocol to assess intra-subject variability. The raw EPI images were pre-processed using SPM8 (FIL, UCL, London, UK). Average perfusion-weighted images (ΔM) for normo- and hyper-capnia were generated by pair-wise subtraction and time averaging over their respective periods. Average grey matter CBF was extracted from the images and CVR was defined as the change in CBF divided by the change in $P_{ET}CO_2$ (mmHg).

Results. Average ΔM images during room-air breathing and hypercapnia for one patient are shown in figure 1. Across all patients, the average $P_{ET}CO_2$ change was 11.6 ± 3.3 mm/Hg. Mean grey-matter CVR values along with the intra- and inter-subject coefficients of variation (CVs) are given in the table below. Time course of grey matter CVR from one patient is shown in figure 2.

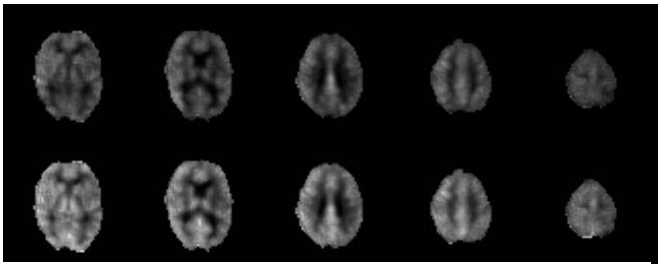

Fig. 1 Average Δ*M* images from one CVD patient while breathing room air (top) and a mixture of $CO_2/O_2/N_2$ (6:21:74%) (bottom). 5 of 12 slices are shown.

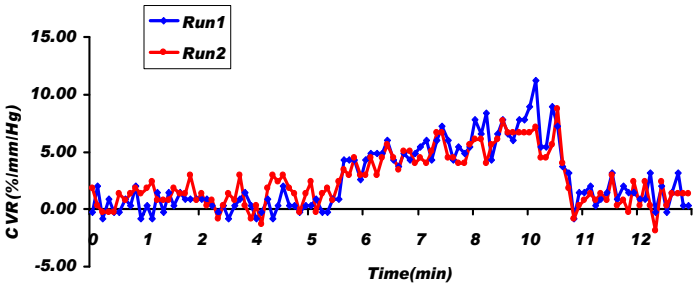

Figure 2: Gray Matter Reactivity Time Series

Grey-matter	CVR (%CBF/mmHg)	CV(%)
Intra-subject (range) **	6.58	2.03
Inter-subject (n=10)	6.54	34.12

** *ICC = 0.992, p>0.01*

Discussion

This study demonstrates the reproducibility of grey-matter CVR measurements in a population of CVD patients. The mean CVR value was in agreement with previous studies[4,5]. The high ICC value indicates that the intrinsic variation in individual CBF response to CO_2 breathing is minimal and will not compromise intra-group CVR comparison. However, the inter-subject CV was approximately twice the value obtained on healthy young volunteers using a similar CO_2 breathing system[5]. This difference could be age-related or perhaps due to vascular disease. Both young and age-matched control groups are part of this on-going study to answer this question. The next step will be to assess regional CVR in cortical regions of the brain associated with cardiovascular regulation and cognition, pre and post cardiovascular rehabilitation.

Reference: [1] Kastrup et al. *J Neurol Sci* 1999;162:127. [2] Last et al, *Diabetes Care* 2007;30:1193-1199. [3] Wang, *Proc ISMRM*, 2007;15:2974. [4] St Lawrence et al. *J Magn Reson Imaging*. 2002;15:628. [5] Winter et al, 18th ISMRM, 2010.