MILD HYPERCAPNIA CAUSES A MEASURABLE CHANGE IN CEREBRAL OXYGEN EXTRACTION FRACTION (OEF)

Rajiv G Menon[1], Charles G Cantrell[1], Edward G Walsh[2], Donald B Twieg[3], and Timothy J Carroll[1]

[1]*Radiology Department, Feinberg School of Medicine, Northwestern University, Chicago, IL, United States,* [2]*Neuroscience, Brown University, Providence, Rhode Island, United States,* [3]*Biomedical Engineering, University of Alabama at Birmingham, Birmingham, AL, United States*

TARGET AUDIENCE: Physicians, Researchers and scientists interested in stroke Imaging

PURPOSE: Oxygen Extraction Fraction(OEF) is a key perfusion marker and shown to be an independent predictor of stroke[1]. We described an MRI technique using PARSE for quantifying OEF previously[2]. Here we show that we can measure dynamic changes in OEF (OEF Reactivity) by inducing mild hypercapnia using a breath-hold experiment. This surrogate measure for cerebrovascular reserve provides complementary information on collateralization, and correlates with favorable outcomes in revascularization therapy.

IMPLEMENTED PARSE SEQUENCE ON A CLINICAL 3T MRI SCANNER

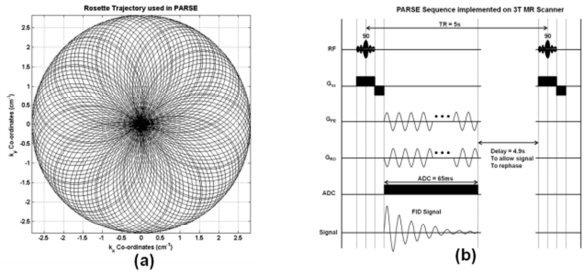

Figure 1. (a) A rosette trajectory is designed for use in the PARSE sequence. (b) The Rosette gradient trajectory is then used in the PARSE sequence implemented on the 3T MRI scanner. Data from a single measurement is 5s and is used to estimate parameter Maps M_0, R_2^* and frequency.

METHODS: A Parameter Assessment by Retrieval from Signal Encoding (PARSE) [3] based MR-OEF sequence was implemented (Reported in Abstract #6354) on a clinical 3T MR scanner (Fig 1). In a series of 5 normal volunteers(M/F 3/2, <age> = 26 ±10 years) we acquired single slice, 5.0 mm thick, 220 mm x 220 mm FOV, 64 x 64 matrix, resolution = 3 x 3 x 5.0 mm^3) 2D PARSE images. Volunteers were tested with 4 conditions: normal breathing, breath-hold at the 1st, 5th and 10th measurement. PARSE acquisitions were taken every 3 seconds through the breath-hold, for a total of 20 measurements. The frequency change maps were calculated from PARSE reconstructions. Spatial ICA analysis was then performed on these frequency maps to separate out other confounding static effects from the dynamic OEF components.

DYNAMIC OEF CHANGES MEASURED USING HYPERCAPNIA

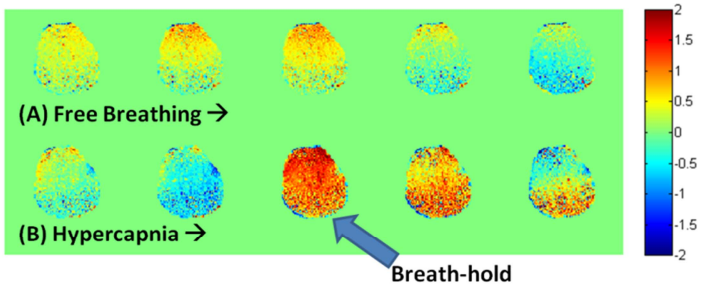

Figure 2: A PARSE acquisition acquired every 3s is used acquire frequency maps that measure dynamic OEF changes that occur during mild hypercapnia. (A) Free Breathing, and (B) Hypercapnia induced by a breath-hold experiment. Shown here are difference maps which have static components removed, to make the dynamic components visible.

MEASUREMENT OF DYNAMIC CHANGES IN OEF (OEF REACTIVITY)

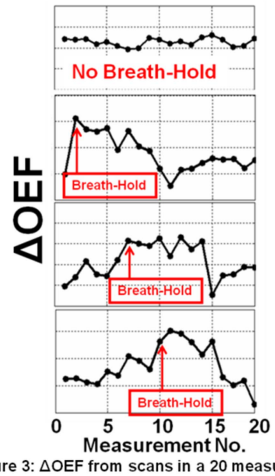

Figure 3: ΔOEF from scans in a 20 measurement series. Free Breathing(top) and Breath-Hold initiated after 1, 5 and 10 measurements(Red Boxes) were acquired to impart a time-dependent modulation on the PARSE signal. Independent Component Analysis (ICA) was used to extract dynamic OEF components.

RESULTS: The change in OEF following a breath-hold experiment is seen in the representative fractional OEF difference maps (Figure 2). The OEF reactivity for different breath-hold conditions is shown in Figure 3. OEF reactivity is seen soon after the breath-hold induced physiologic stress.

DISCUSSION/CONCLUSION: While the free-breathing condition ΔOEF does not change measurably, the mild hypercapnic conditions do cause a measurable change in ΔOEF. This technique can provide supplemental information regarding the vascular reserve in patients who typically receive diamox/acetazolamide challenge to determine information on collateralization. The speed of the MR-OEF technique allows for multiple measurements in a single breath-hold experiment thus allowing measurement of dynamic OEF changes. Clinical validation of this technique on patients needs to be done to establish the efficacy of this technique.

REFERENCES: [1] Derdeyn CP Brain 2002 125, 595-607;[2]Menon, RM et al Proc ISMRM 2012 # 4219 [3] Twieg DB MRM 2002 50:1043-52;

ACKNOWLEDGEMENTS: NIH/NIBIB T32 EB005170, NIH/NHLBI R01 HL088437