

## Determination of CMRO<sub>2</sub> changes During Hyperbaric Exposure

Damon P Cardenas<sup>1</sup>, Eric Muir<sup>1</sup>, Shiliang huang<sup>2</sup>, and Timothy Duong<sup>1</sup>

<sup>1</sup>Radiology, University of Texas Health Science Center at San Antonio, San Antonio, Texas, United States, <sup>2</sup>MRI, Research Imaging Institute, San Antonio, Texas, United States

**TARGET AUDIENCE.** Neuroscientists, physiologists on hyperbaric pressure

**PURPOSE.** Hyperbaric oxygen (HBO) treatment is commonly used for ailments such as diabetic gangrene and decompression sickness, and is being used to treat patients suffering from neurological impairments such as stroke or traumatic brain injury (TBI). The key to the therapy is that an increase of [O<sub>2</sub>] is supplied to the tissue, increasing metabolic capabilities. This research assesses the cerebral metabolic rate of oxygen (CMRO<sub>2</sub>) during: normobaric air (NB) normobaric oxygen (NBO), hyperbaric air (HB), and hyperbaric oxygen (HB) conditions. Our hypothesis is that CMRO<sub>2</sub> will increase under HBO since a potentially high metabolic demand for oxygen can be met.

**METHODS.** A custom-made hyperbaric chamber was constructed from pvc for use in the MRI scanner<sup>1</sup>. Male Sprague-Dawley rats (n=4, 325±50g) were anesthetized by using a bolus of α-chloralose at 60mg/kg i.v. (tail vein) and a 30mg/kg/hr infusion 30 minutes later. The rats were imaged under spontaneous breathing conditions. Respiration and heart rate were monitored and rectal temperature maintained at 37°C. Electrodes were placed into both of the rat's forepaws for stimulation. The chamber was pressurized to 3ATA (atmospheres absolute) with normal air. The rat was provided a separate gas-line within the chamber that allowed either air or 100% O<sub>2</sub> to be inhaled by the animal. The gas and pressure paradigm includes data from: normal air inhaled at normal pressure (NB), 100% O<sub>2</sub> inhaled at normal pressure (NBO), normal air inhaled during high pressure (HB), and 100% O<sub>2</sub> inhaled during high pressure (HBO). Importantly, CO<sub>2</sub> gas challenges (2mins air, 3mins 5%CO<sub>2</sub>-air balanced, 5mins air) were conducted at both normobaric (NBCO<sub>2</sub>) and hyperbaric (HBCO<sub>2</sub>) conditions.

MRI was performed at 7T with a 2cm surface coil. An EPI sequence with an FOV=25.6x25.6x30mm, matrix=96x96, TE=20ms, TR=3s, seven 1.5mm thick slices was used for all scans. Regions of interest (ROIs) were drawn onto the images in the S1 region and used to find percent changes between stimulation and resting periods. Evoked BOLD, CBF, and CMRO<sub>2</sub> changes in response to forepaw stimulation and CO<sub>2</sub> challenges were calculated<sup>2</sup>. Statistical analysis was completed using paired t-tests with bonferroni-holm correction.

**RESULTS.** When pressurized, there are large increases in BOLD and CBF response to CO<sub>2</sub>, leading to a much higher M-value; all these values are statistically significant (Table 1). CMRO<sub>2</sub> values calculated using data from both the NBCO<sub>2</sub> and HBCO<sub>2</sub>. M-values derived from NBCO<sub>2</sub> were applied to NB and NBO (Figure 1), while M-values derived from HBCO<sub>2</sub> were applied to HB and HBO conditions. Evoked CMRO<sub>2</sub> data was repeatedly obtained (Figure 1). Evoked CMRO<sub>2</sub> changes at each of the four gas conditions were not significantly different (Figure 2).

**DISCUSSION.** From Table 1, it is evident that CO<sub>2</sub> pressure dramatically affects M-value calculations, which in turn affects CMRO<sub>2</sub> values. These results, in addition to factors that may alter a and bta values could confound CMRO<sub>2</sub> results. Despite these factors, we were able to achieve consistent evoked response in CMRO<sub>2</sub> (Figure 1).

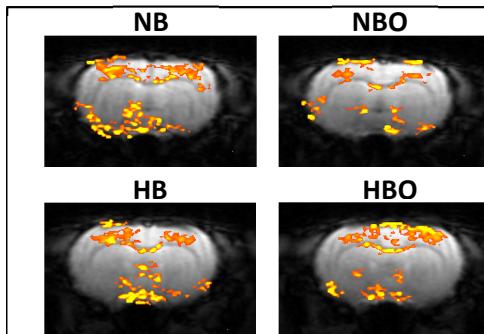
Contrary to our hypothesis, there was no significant difference in the CMRO<sub>2</sub> across the four conditions. A lack of significant difference has been seen before between NB and NBO<sup>2</sup>. The findings that HB and HBO do not affect CMRO<sub>2</sub> could mean that increases in [O<sub>2</sub>] are in excess of metabolic demand. This is consistent with electrophysiological findings that SEP data is not different at HBO<sup>3</sup>.

**CONCLUSION.** Based on these results, there is not a significant benefit or detriment in CMRO<sub>2</sub> at the NBO, HB, or HBO condition, implying that [O<sub>2</sub>] availability is not a limiting factor in neurological activity. Trends in the CMRO<sub>2</sub> evoked response seem to indicate that at the HB condition, CMRO<sub>2</sub> may increase, making it a good candidate for future studies involving metabolic activity. Future studies will involve use EEG to confirm proper neurological activity, and varying HB pressure to identify pressures more conducive to increased CMRO<sub>2</sub> activity.

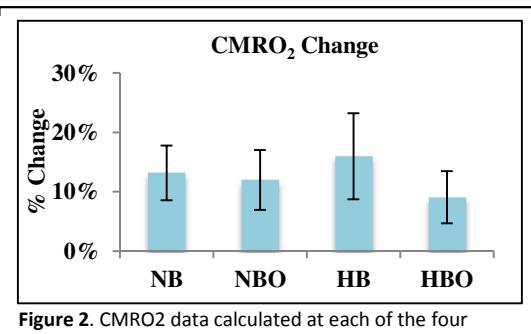
**REFERENCES.** 1) Muir et al. *MRM* 2013 (in press). 2) Sicard et al. *Neuroimage* 2005; 850-858. 3) Lindaur et al. *JCBFM* 2010; 30:757-768.

**Table 1.** CO<sub>2</sub> gas challenges (n=4, mean±SEM, \* p<0.05)

	Normobaric	Hyperbaric
CBF Change (%)	32.4 ± 20.0	171 ± 79.0*
BOLD Change (%)	2.0 ± .61	9.0 ± 4.0*
M-Value	0.088 ± .035	0.14 ± .044*



**Figure 1.** CMRO<sub>2</sub> activation map. Map from single animal, representative of quantitative calculations.



**Figure 2.** CMRO<sub>2</sub> data calculated at each of the four different conditions (HBCO<sub>2</sub> used where appropriate. Data represented as mean ± SEM. n = 4