Acquisition of Basal and Evoked Potential CBF Response During Hyperbaric Exposure

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TARGET AUDIENCE. Neurophysiologists of hyperbaric pressure. Scientists interested in the role of O_2 on BOLD fMRI responses.

Table 1. (n = 6)	NB	NBO	HB	HBO
Respiration (bpm)	78.2 ± 5.5	67.8 ± 5.9*	58.9 ± 9.4*§	56.3 ± 6.3*§
Heart Rate (bpm)	385 ± 39	375 ± 38	357 ± 45	372 ± 41
SpO_2 in %	94.7 ± 2.4	99.1 ± 0.5*	99.1 ± 0.6*	99.2 ± 0.4*

PURPOSE. Cerebral blood flow (CBF) is tightly regulated. There are substantial interests in the effects of oxygen availability on neurovascular coupling and the response of CBF to neural activation. In this study, we evaluated CBF responses to forepaw stimulation in rats under i) normobaric air (NB), ii) normobaric oxygen (NBO), iii) hyperbaric air (HB), and iv) hyperbaric oxygen (HBO). We hypothesize that basal CBF will decrease with increasing inhaled [O_2] due to oxygen-induced vasoconstriction and that the stimulus-evoked CBF change is independent of inhaled [O_2].

METHODS. A custom-made hyperbaric chamber was constructed for use in the MRI scanner[1]. Male SD rats (n=9, 325±50g) were anesthetized with a bolus of α-chloralose at 60mg/kg iv 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. Both forepaws were stimulated simultaneously in series (0.3mA, 3Hz, 0.3ms).[2] The rat was provided a separate gas-line within the chamber that allowed either air or 100% O_2 to be inhaled by the animal. Measurements were made during: i) normobaric air, ii) normobaric oxygen, iii) 3 atmospheres absolute (ATA) hyperbaric air, and iv) 3ATA hyperbaric oxygen.

Basal CBF and CBF fMRI were acquired using continuous ASL EPI technique at 7T using a 2cm brain surface coil and a neck-labeling coil, with FOV=25.6x25.6x30mm, matrix=96x96, TE=20ms, TR=3s, and seven 1.5mm thick slices. Regions of interest (ROIs) in the S1 region were used to find percent changes between stimulation and resting periods. Basal CBF was calculated. Evoked CBF changes in response to forepaw stimulation were calculated.[2] Statistical analysis was completed using paired t-tests with Bonferroni-Holm correction.

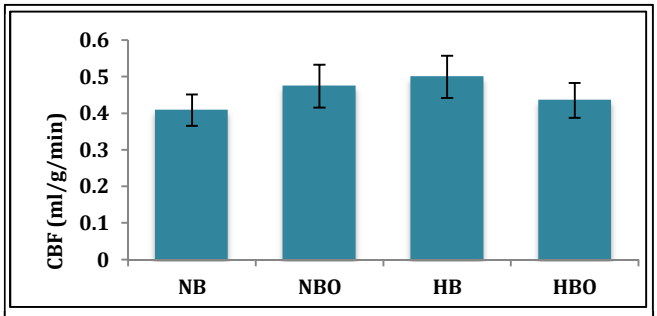

Figure 1. Basal CBF (whole brain) in mean±SEM, n=9.

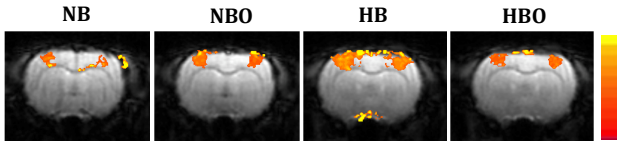

Figure 2. CBF activation maps in response to forepaw stimulation (n=9). Color bar indicates 10-60% changes.

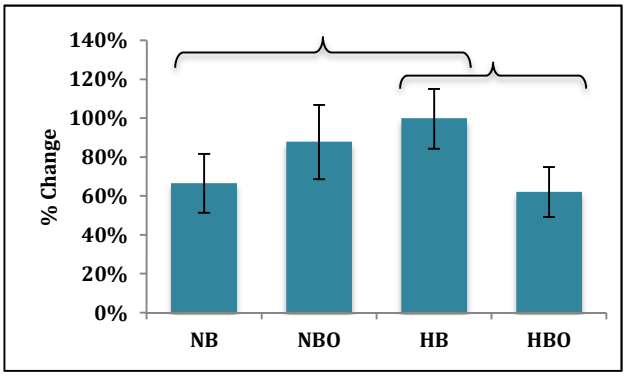

Figure 3. Stimulus-evoked CBF % changes. Data presented as mean ± SEM. Brackets indicate significance (p<.05). n = 9

RESULTS. Respiration rate decreased and SpO_2 increased. Heart rate didn't change significantly with increasing inhaled [O_2] (Table 1). Basal blood flow was not significantly different among the four conditions (Figure 1). Forepaw stimulation evoked reproducible activations in CBF fMRI in the bilateral primary somatosensory cortices under all 4 experimental conditions (Figure 2). Group data showed that under HB, CBF % changes were statistically different from NB and HBO (Figure 3). No other statistical relevance was found.

DISCUSSION. Basal CBF among the four conditions were not statistically different, contrary to our hypothesis. CBF at NBO, under spontaneous breathing, has previously been shown to be not significantly different from CBF at NB[2]. The effect of HBO on basal CBF has not been clearly established, increasing in some cases[3] and decreasing in others[4]. We assume, based on decreased repiration in non-NB conditions (Table 1), that there is increased [CO_2], which typically causes vasodilation. This effect may be counteracted, however, by increases in [O_2], which has a vasocontrictive effect. It has been noted that dissolved arterial [O_2] could confound our results, as it has been observed that high arterial [O_2] can decrease T1.

Stimulus-evoked CBF increases had a trend of increasing at moderately high inhaled [O_2] (HB and NBO), but then decreased again at HBO. This suggests that functionally evoked CBF responses are in someway regulated by blood or tissue oxygenation, contrary to our second hypotheses. It has been suggested that neurons use an alternative mechanism, other than [O_2] or [Hb/dHb] to incite changes in CBF[3].

CONCLUSION. As HBO and NBO are commonly used to treat a number of diseases, improved understanding of tissue oxygenation and blood flow, as well as evoked responses under each of our experimental conditions, have potential clinical implications. The finding that HB and HBO have such a disparity in measured evoked response merits investigation in future work.

REFERENCES. 1) Muir et al. *MRM* 2013 (in press). 2) Sicard et al. *Neuroimage* 2005; 25:850. 3) Lindaur et al. *JCBFM* 2010; 30:757-768. 4) Demchenko et al. *J Appl Physiol*, 2000; 88:1381-1389