The effects of Hypo-baric pressure on Cerebral Blood flow

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TARGET AUDIENCE: Neuroscientists and physiologists, researchers in altitude, perfusion

PURPOSE: High altitude sickness (experienced by mountain climbers and U2 pilots) could lead to a broad spectrum of disorders in the brain and other organs. For the brain, they include headache, irritability, dizziness, vomiting, confusion, etc. White matter hyperintensity, metabolic changes, and brain swelling among others, associated with acute and chronic high altitude exposure have been reported[1]. These studies investigated high altitude sickness post exposure. It would be interesting to study how the brain response and adapt to acute high altitude sickness. In this work, we constructed a hypobaric chamber for animal MRI scanner and performed cerebral blood flow (CBF) cerebrovascular reactivity during acute hypobaric exposure equivalent to pressure at 10000 feet above sea level.

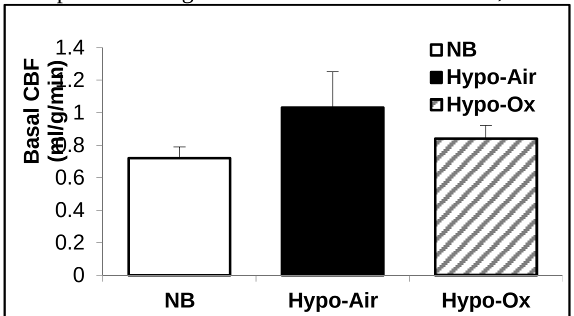

Figure 1

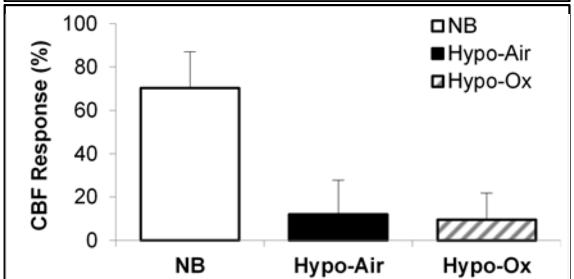

Figure 2

METHODS: A custom-made hypobaric chamber was constructed for use in the MRI scanner, consisting of a cradle for the animal which slid into a PVC pipe and was then sealed on both ends. Cables of the coils, gas lines, and lines of physiological monitoring equipment were passed through tight fitting holes on the two ends of the chamber and sealed with silicone sealant as needed. The chamber pressure was reduced with a vacuum pump to 0.67±0.02 atm absolute (equivalent to an altitude of ~3000m). A separate gas line with a nose cone was used to deliver air and/or oxygen to the animal. A vent in the chamber allowed fresh air flow.

Male Sprague-Dawley rats (n=4, 286-445g) were anesthetized with 1.5g/kg urethane i.p. and imaged under spontaneous breathing conditions. Arterial oxygen saturation, heart rate, and respiration rate were monitored and rectal temperature maintained at 37^{o}C. Animals were imaged under 1) normobaric air, NB; 2) hypobaric air, Hypo-Air; and 3) hypobaric oxygen, Hypo-Ox (air+O2 mixture to maintain sO2 at comparable levels as normobaric air).

MRI was performed at 7T with a 2cm surface coil. 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 cortex were used to find percent changes between stimulation and resting periods. Statistical analysis used paired t-tests with Bonferroni-Holm correction.

RESULTS: Cortical basal blood flow under hypobaric pressure, both with air and oxygen, trended towards an increase, but the data was not statistically significantly different (**Fig 1**). Hypobaric pressure, both with air and oxygen, trended towards decreasing cortical cerebrovascular reactivity, but the decrease was not statistically significant (**Fig 2, 3)**.

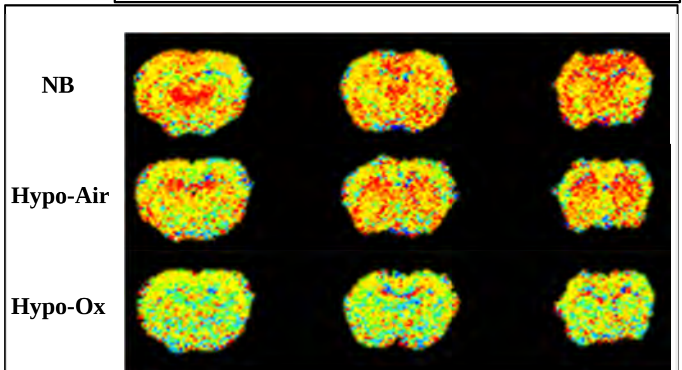

Figure 3

DISCUSSION & CONCLUSION: The advantages of MRI compared to most other imaging modalities are that global, acute-phase CBF and cerebrovascular reactivity can be observed. The finding that basal CBF decreases under hypobaric air conditions is consistent with what is found in literature[2]. Since the hypobaric oxygen counteracts the effects of hypoxia, it is expected that the cerebral blood is not as high as hypobaric air.

Hypobaric hypoxia is known to have an effect on cerebrovascular autoregulation[3]. The hindered cerebrovascular reactivity during hypobaric conditions could provide insight as to why cerebrovascular autoregulation is affected. Future studies will investigate the effects of hyperbaric pressure on evoked fMRI responses.

Reference: 1) Clark, *Postgrad Med J*, 2006. 2) Pagani et al, *Acta Physiol Scand*, 2000. 3) Subudhi, *Stroke*, 2010