

Cerebral blood flow of the rat under hyperbaric and hyperbaric oxygen conditions

Eric R Muir¹, Damon Cardenas¹, Guang Li¹, John Roby¹, and Timothy Duong^{1,2}

¹Research Imaging Institute, UT Health Science Center, San Antonio, TX, United States, ²Ophthalmology, UT Health Science Center

INTRODUCTION: Studies of brain function under high oxygen conditions such as hyperbaric (HB) or hyperbaric oxygen (HBO) could help to understand regulation of neurovascular coupling. Additionally, HBO has been used as treatment for various neurological diseases, so a better understanding of brain physiology and function under such conditions could lead to a better understanding of the effects of HB. Under HB conditions, there will be more oxygen, which is vasoconstrictive on cerebral vasculature, so cerebral blood flow (CBF) may be reduced. The aim of this study was to use arterial-spin labeling MRI to study the effect of HB and HBO on CBF in rats. A HB chamber was built that could be put in the MRI scanner, allowing MR acquisition during HB conditions.

METHODS: A custom-made hyperbaric chamber was constructed to be used in the MRI scanner, consisting of a cradle for the animal which slid into a PVC pipe that 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 grease and glue as needed. The chamber was pressurized with air to 4 atmospheres absolute. A separate gas line with a nose cone was used to deliver 100% oxygen to the animal. A vent was put in the chamber to allow fresh air flow through and to prevent buildup of high concentrations of oxygen under HBO. The flow rate of the oxygen was set so as to keep the vented gas less than 30% O₂. Animals were imaged under normobaric air (NB), normobaric oxygen (NBO), HB, and HBO conditions.

Male Sprague-Dawley rats (n=4, 286-377g) were anesthetized with 1.5g/kg urethane i.p. and imaged under spontaneous breathing conditions. Respiration and heart rate were monitored and rectal temperature maintained at 37°C. Animals were placed in the holder and put into the HB chamber and put in the MRI scanner. MRI was performed at 7T with a surface coil (diameter=2cm) used for imaging. CBF maps were acquired using arterial spin labeling with label duration=2.5s, post label delay=250ms, acquired with EPI with seven 1.5mm thick slices, FOV=25.6x25.6mm, matrix=96x96, TR=2.9s, TE=10.8ms. CBF was calculated as in (1). Potential blood oxygenation level dependent (BOLD) changes were also analyzed from the ASL EPI data, averaging label and non-label images.

RESULTS: **Fig 1** shows CBF in ROIS of the brain under NB, NBO, HB, and HBO conditions. One way ANOVA was run separately on each ROI, with only the caudate putamen ROI having significant difference (p=0.006). A Tukey-kramer post hoc test was run giving, that CBF under HBO was significantly less than NB and HB. **Fig 2** shows the CBF % changes in the caudate putamen relative to NB. **Fig 3** shows BOLD % changes relative to NB condition. BOLD signal tended to increase under NBO and HBO conditions, but did not change much under HB.

DISCUSSION: HB at 4 atm would increase the partial pressure of O₂ from 160 to 638 mmHg and HBO would increase to 3040 mmHg. CBF had a tendency to decrease under hyperoxia conditions, with some significant CBF decreases under HBO. HB did not have much effect on CBF, despite the increased oxygen of the high pressure air. Overall, CBF was somewhat low compared to other studies using isoflurane which is a vasodilator (1), likely due to the use of urethane. Use of volatile anesthetics could be difficult under HB pressure though. Also, physiological measurements of blood pressure and blood gas were not done due to the difficulty of having high pressure inside the chamber, and remain to be explored. Signal intensity was increased under hyperoxia conditions, as expected, although much time passed between acquisition of all conditions, so signal intensity drift could have occurred, obscuring BOLD effects. This study demonstrates the feasibility of acquiring CBF MRI under HBO conditions using a specially made hyperbaric chamber. CBF may be decreased under HBO, although further studies are needed to determine with more certainty. These methods will be used to study the effects of HB and HBO on functional MRI in the future.

Reference: 1) Shen et al, JCBFM 2005, 25:1265.

