Detection of 100% oxygen induced changes in retina using magnetic resonance imaging: a human study

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INTRODUCTION: Sustained oxygen deprivation can result in significant, permanent retinal dysfunction that is believed to trigger retinal structural or functional pathology irreversibly. Inner retinal oxygenation response(ΔPO2) that is inferred from currently available techniques have substantial limitations and there are few studies exploring ΔPO2 mechanism in the live human retina. In this study, MRI, employing T1WI, was used to try to detect changes in ΔPO2 following 100% oxygen inhalation in human subjects[1,2]. Based upon the acquired ΔPO2 information from animal experiments, we analyze the MRI data to elucidate the following hypotheses: ΔPO2 in preretinal vitreous water following 100% oxygen inhalation detected by MRI is in accordance with the retinal blood flow distribution.

MATERIALS AND METHODS：**Subjects:** Eleven healthy volunteers (29.64±5.5 years old) participated in the study after written informed consent was obtained. **MRI acquisition:** All the subjects received scans under room air and 100% oxygen inhalation in order with different interval. All images were acquired on a 1.5 T GE Infinity scanner with Excite gradients using a standard GE ocular surface coil. The imaging parameters for SPGR acquisition are: TR/TE = 9.05/4.37 msec; flip angle = 15°; FOV=24*24cm; slice thickness = 5 mm; matrix=256 × 256; NEX =2; scan time = 38sec. The scaned images were centered on the lens and opticus, and the subjects were asked to refrain from blinking during the SPGR image, and to blink if needed in the one-third of scan time for 3-5s rest period[3]. **Data Analysis:** Among the 11 participants, one set of data was eliminated due to excessive eye movement. To correct for any movement within the slice plane, all images were calibrated by AFNI and then data were analyzed with NIH IMAGE. ΔPO2 images were analyzed based on Berkowitz' work[3,4], as illustrated in Figure 1. ANOVA was employed to assess the difference in time and regional differences in ΔPO2 using the SPSS (13.0) software package. A probability value of $P < 0.05$ was considered as statistically significant.

RESULTS：(1)In general, ΔPO2 was not uniform panretinally, changes in oxygenation response were spatially inhomogeneous; (2)During the initial phase of 100% oxygen inhalation, preretinal vitreous water signal(PVWS) in region of papilla optica increased rapidly, but in the other regions , on the contrary, signals declined; In the following later period, ΔPO2 panretinally was fluctuated and increased slowly and attained homeostasis. However, there was no statistically significance(P>0.05) between either time point; (3)After hyperoxia, delayed-enhancement of PVWS in other than papilla optica region occurred, and then dropped down, as shown in Figure 2.There was no statistically significant difference (P>0.05) between either time point after hyperoixa.

DISCUSSION AND CONCLUSION：Although choroidal blood flow played an important role on oxygen supply, it had only weakly vasoconstriction in response to pure oxygen. So the changes of ΔPO2 detected by MRI were primarily the result of retinal microvessels in response to pure oxygen. During the initial phase of 100% oxygen inhalation, we postulate that the characteristic of retinal ΔPO2 synchronously with time and region was related to the retinal microvessels' distribution and its effect to hyperoxia. Microvessels located in peripheral regions vasoconstricted strongly in response to hyperoxia , and its blood flow and oxygen diffusion decreased[5], ΔPO2 declined. Another possibility which should be considered was that red blood cell flow may be more dramatically affected by hyperoxia-induced vasoconstriction in the retina[6], which induced an additional increase in vascular resistance. After hyperoxia, it may be related to the delayed oxygen diffusion in the regions of reduction in red blood cell velocity. These results reveal that hyperoxia can induce region-specific signal changes in preretinal vitreous water. Regulation activity of retinal vessels network may be the mechanism of 100% oxygen inhalation. Moreover, MRI is a valuable tool for investigation of ΔPO2 and exploring the mechanism of retinal oxygenation response pathologically in vivo.

Figure 1.

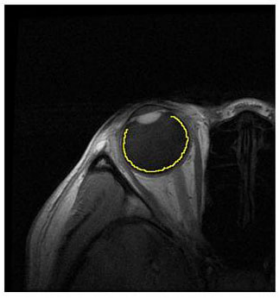

Figure 2.

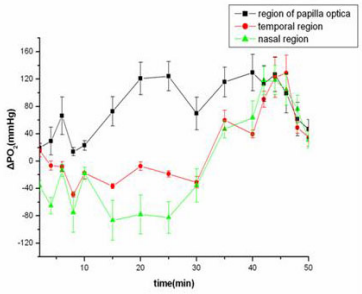

Figure 1. Mapping of ROI. ΔPO_2 measurement was calculated by the curved line(yellow) drawn in the preretinal vitreous next to the retina.**Figure 2.** Mean±SEM time-courses plots of region-specific ΔPO_2 variables measured at different time. Plots were taken from both conditions in the course of and after 100% oxygen inhalation.

RECEFENCE：：

1.Berkowitz BA et al. Invest Ophthalmol Vis Sci 1999;40:2100–2105. **2**.Berkowitz BA. Invest Ophthalmol Vis Sci 1996;37: 2089–2098. **3**.Berkowitz BA et al. Magn Reson Med. 2001;46:412-416. **4**.Trick GL et al.Invest Ophthalmol Vis Sci 2006;47:1612-1619.**5**. Li Y et al. Neuroimage.2008;39:1744-1751. **6**. Kiss B et al. Microvasc Res.2002;64:75-85.