Vision and Oxygen Inhalation Affect Mitochontrial Activity: A 31P Magnetic Resonance Spectroscopy Study

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Introduction

Brain energy metabolism can be assessed by using ^{31}P magnetic resonance spectroscopy (MRS) to measure changes in the intracellular pH and relative concentrations of adenosinetriphosphate (ATP), phosphocreatine (PCr), and inorganic phosphate (Pi). ^{31}P MRS is much helpful for elucidating the etiology of many brain diseases, disease diagnosis, treatment, and pharmacology improvement as well. Previous study showed that human brain is active in sedentary status and sensitive to oxygen supplementation. However, less concern is addressed to study whether vision will affect brain activity or not. In this study, we compared the difference of brain metabolites before and after oxygen inhalation, meanwhile eyes closed and eyes opening, by ^{31}P MRS. We wish to know the relationship between oxygen inhalation and mitochondrial activity, and relationship between vision and mitochondrial activity as well. These will be helpful to measure cerebral metabolic rate of oxygen ($CMRO_2$) under different circumstances and benefit for clinical oxygen administration.

Materials and Methods

Eleven healthy volunteers underwent ^{31}P MRS examination. Seven volunteers took part in the first stage of the study, before and after breathing hyperoxic air (100% O_2) only, with eyes closed. Four volunteers participated in the second stage, 2 scans with eyes closed same as the first stage, and the 3rd scan breathing hyperoxic air (100% O_2) with eyes opening. All volunteers were from MR research team and gave informed written consent. All healthy volunteers did not smoke. The studies were performed on a 3-T GE scanner. Nasal cannula was placed before MR examination. A spin echo MRS sequence was utilized for ^{31}P scans with a GE service coil. TR was 2000 msec and TE 35 msec with 128 scan averages. The voxel size was 4x4x4 cm^3 placed in the occipital lobes. Data were processed offline using the SAGE/IDL software. Baseline and phase corrections were performed. Peak integral values of inorganic phosphor, phosphocreatine, γATP, αATP, βATP, and "potential of hydrogen" (pH) were measured.

Results

Good ^{31}P spectra were obtained for all volunteer studies. The examples of ^{31}P MR spectra for 3 times of scans are shown in Figure 1. From visual inspection, we can observe decreased Pi peak and increased γATP, αATP, and βATP peaks on Figure 1C, the 3rd scan breathing hyperoxic air with eyes opening. Figure 1A is the example of ^{31}P spectra without 100% oxygen inhalation. Figure 1B is the ^{31}P spectra with 100% oxygen inhalation. Decreased Pi peak integral values and increased peak integral values of γATP, αATP, and βATP can be measured using SAGE/IDL software, after 100% oxygen inhalation with eye closed. Compared with first scans, peak integral values of γATPs were increased from 0.75 % to 15.97 % (5.76±4.03) on second scans; αATP from 1.21% to 16.05% (6.23±5.35); βATP from 1.01% to 7.12% (2.67±2.04). Compared with second scans, peak integral values of γATPs were increased from 3.53 % to 9.12 % on third scans of 4 volunteers; αATP from 3.65% to 10.72%; βATP from 2.45% to 8.82%. The pH values among 3 scans were not changed obviously.

Discussion

Oxidative phosphorylation and the generation of adenosine triphosphate (ATP) are the central functions of mitochondria. However, the function of mitochondria can be influenced and manipulated by many physiological and pathological conditions. In this study, we observed the influence of breathing hyperoxic air and vision on brain mitochondria in sedentary healthy volunteers. Brain mitochondrial activities were increased and more ATPs were produced after oxygen inhalation in healthy volunteers. Vision will affect mitochontrial activity also. More energy is needed in visual status. We should point out that our results would have been more compelling if the data had not been acquired on the research team, and with a larger number of subjects. One drawback of this study was that we used peak integral values to express our results because we are currently engaged in developing a reliable and accurate method to quantitatively measure the metabolite concentrations using ^{31}P MRS.

References

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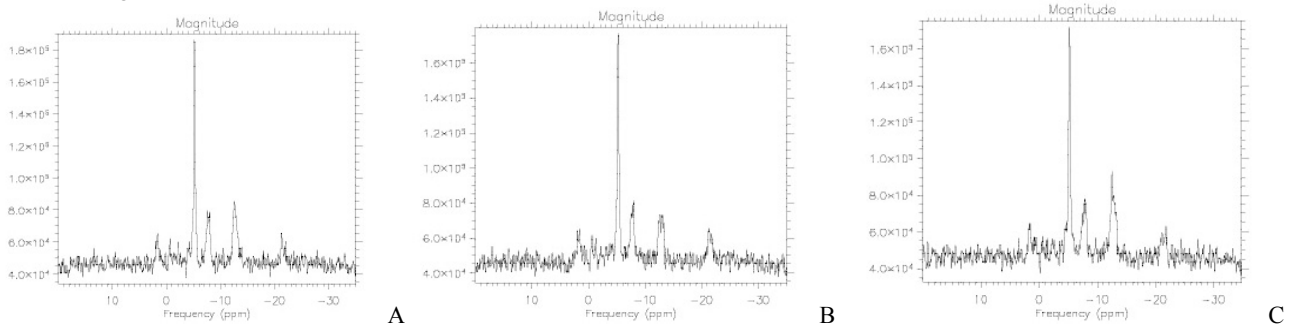

Figure 1. A is the example of ^{31}P spectra without 100% oxygen inhalation and with eyes closed. B is the ^{31}P spectra with 100% oxygen inhalation and with eyes closed. C is the ^{31}P spectra with 100% oxygen inhalation and with eyes opening. Decreased Pi peak and increased peaks of γATP, αATP, and βATP can be visually observed on C.