Dynamic changes in brain bioenergetics during apneic excursions in obstructive sleep apnea

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Introduction

The repetitive collapse of the upper airway in obstructive sleep apnoea (OSA) means that the brain of sufferers is exposed to frequent transient hypoxic episodes. The loss of cerebrovascular reactivity in sleep, and particularly in OSA, means that the physiological compensatory mechanisms may not ensure adequate brain oxygen levels. The effect of mild hypoxia on brain bioenergetics has not previously been examined on short time scales. Here, we used ^{31}P magnetic resonance spectroscopy on a seconds time scale to examine brain bioenergetics during the time course of apnoeic hypoxia that occurs in OSA subjects.

Methods

We studied 13 males with newly diagnosed severe OSA with ^{31}P MRS at 1.5T using a Philips Intera system and a 10 cm surface coil placed over the left temporal lobe (Fig. 1). Subjects were studied at 7 am after a night of sleep deprivation. All spectra were acquired using a pulse and collect sequence (TR = 2s) with an adiabatic pulse to deliver increased S/N and depth penetration and no phase cycling. A series of baseline spectra (16 transients) were obtained while the subject was awake followed by a number of time series (128 single scans). SaO_2 was recorded by pulse oximeter with every scan (one every 2 s). 5 subjects had hypoxic excursions (SaO_2 ≥10% < baseline) while 7 did not. Typical SaO_2 traces are shown in Fig. 2. Individual spectra were reconstructed from the time series to give spectra ≥8 transients (Fig. 3) obtained either within 2% of maximum SaO_2 or ≥ 10% < baseline. Spectra were processed using the AMARES algorithm in jMRUI with the Pi linewidth soft constrained. Estimates were obtained for PME, Pi, PDE, PCr, pH and the three peaks of nTP as well as the coil phantom. These data were compared using a linear mixed effects statistical model with saturation status as a fixed effect and subject identifier as a random effect.

Fig. 1 Phantom shows centre of coil

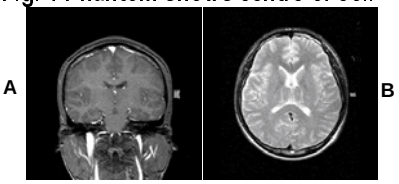


Fig. 2. Typical SaO_2 traces

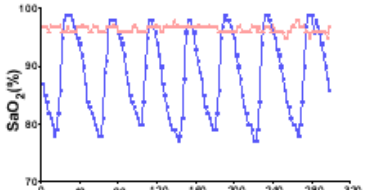
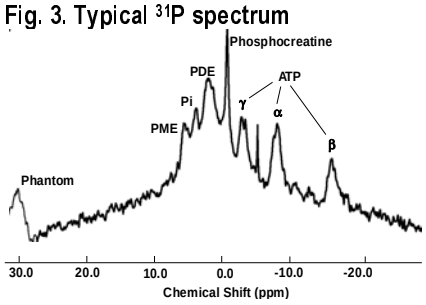


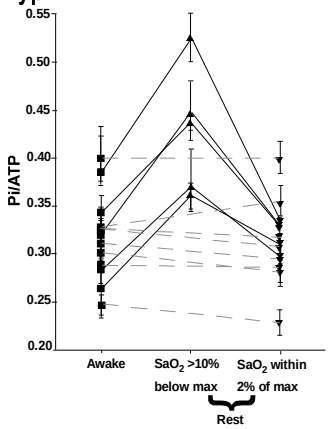
Fig. 3. Typical ^{31}P spectrum



Results

There was a significant effect of saturation status on Pi/ATP (Fig. 4), Pi/total, Pi/phantom, Pi/PDE, Pi/PCr, PCr/ATP and ATP/total. There was no effect on PME/total, PDE/Total, PCr/Total, pH, Phantom/total or PCr/Phantom. Taken together, these data show dynamic increases in Pi with decreases in ATP with no concomitant changes in PCr, PME, PDE or pH.

Fig. 4. Effect of transient hypoxia on Pi/ATP.



Discussion

Cerebrovascular reactivity is reduced in sleep and further reduced by OSA[1]. These data show that mild hypoxia has significant bioenergetic effects in this population. Hypoxia in sleep may have more deleterious effects than when awake. The creatine kinase reaction is not engaged in this case.

References

1.Placidi, F., et al., *Impairment of daytime cerebrovascular reactivity in patients with obstructive sleep apnoea syndrome.* Journal of Sleep Research, 1998. **7**: 288-292.