Carbogen inhalation increases oxygen transport to brain tissue

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ABSTRACT

Hyperoxic therapy for cerebral ischemia is suspected of reducing cerebral blood flow (CBF), because of a vasoconstrictive effect of oxygen on cerebral arterioles. We now claim that vasodilatation must predominate when 5% CO_2 is further added to the inhaled oxygen (known as carbogen). This thesis presents a systematic test of this hypothesis in three different physiological states: study I (normoxia), study II (hypoperfusion) and study III (hypoxemia). Using positron emission tomography (PET), we measured CBF during inhalation of pure O_2, carbogen (5% CO_2 + 95% O_2) , and atmospheric air. Ten healthy volunteers and six patients with occlusive carotid artery disease were tested in study I and study II respectively. Arterial blood gases were recorded during administration of each gas. In study III five volunteer breath-hold divers were scanned in two different breath-holding conditions: breath-holding after breathing atmospheric air, and breath-holding after breathing carbogen (5% CO_2 + 95% O_2).

In study I inhalation of carbogen significantly increased global CBF, whereas pure oxygen decreased global CBF. The $CMRO_2$ generally remained unchanged, except in white matter during oxygen inhalation relative to condition of atmospheric air inhalation. Using subjects from study I as a control group for study II, we found no significant interaction between group and condition (p=0.25), indicating similar effects of oxygen and carbogen in the two groups. Contrasts in the additive ANOVA model showed that carbogen significantly increases CBF (p=0.0001), while oxygen insignificantly reduces CBF (p=0.06). We found no significant differences between group SaO_2 or PaO_2 values, whether subjects received oxygen or carbogen. Considering normal breath-holding as the baseline, PET measurements in study III showed that inhalation of carbogen (relative to air) before breath-holding resulted in approximately 18% higher ΔCBF, 3% lower $\Delta CMRO_2$ and 37% lower ΔOEF on average. The present study demonstrates that concomitant increases of CBF and Sa_{O2} more readily happen with carbogen than with oxygen. As a consequence, carbogen relative to oxygen more efficiently improves the oxygen transport to brain tissue. The present results are promising, but insufficient to make any conclusions regarding the therapeutic benefits of carbogen in acute stroke patients. Further studies are needed to assess the applicability of carbogen in brain tissue with severe hypoperfusion. Furthermore, future safety studies have to rule out possible side-effects of the long-term use of carbogen.