Microvascular perfusion during acute hypoxic exposure

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Abstract

Hypoxia is any state that leads to a severity-dependant reduction in the arterial saturation of oxygen (SaO_2). It is commonly observed at altitude and in chronic conditions such as COPD and sleep apnoea, all of which may be accompanied by a degree of cognitive deficit. Historically, the neurovascular reaction to falling SaO_2 is thought to be an increase in global cerebral blood flow (CBF) to preserve the cerebral delivery of oxygen and maintain cerebral metabolic rate for normal neural functioning. This response leaves observed cognitive deficits encountered during prolonged hypoxia difficult to explain. However, a recent investigation utilising a single delay arterial spin labelling (ASL) technique during acute and prolonged hypoxia showed that despite a global increase in CBF, on the regional level CBF (rCBF) was not equally preserved (Lawley, Macdonald, Oliver & Mullins, 2014). While extensive regions of the frontal cortex did display increases in rCBF, regions that are known to constitute the default mode network (DMN) had unexpected reductions in rCBF. These observed reductions in rCBF may be related to some of the cognitive deficits seen during hypoxia. Our current study aimed to replicate and extend the previous novel rCBF findings with increased brain coverage to further characterise the neurovascular response to hypoxia.

Methods: Fifteen Participants over two separate sessions were exposed to normoxia and acute (3 hours) normobaric poikilocapnic hypoxia (12% oxygen) before having a whole brain resting state ASL scan. ASL data were collected using a single delay scan (Slices = 16, FOV = 256x256x105 mm, resolution inplane = 2.5 mm^2, Delay = 1600 ms) on a Philips 3T MRI system. CBF maps for both hypoxia and normoxia conditions (N= 15) were calculated using the basil (Chappell, Groves, Whitcher & Woolrich, 2009) routine in FSL, and then compared using RANDOMISE (Winkler et al., 2014) in FSL with cluster-based extent thresholding, and masked with a grey matter mask, to reveal regions where CBF significantly differed between the two conditions.

Results: Two significant clusters (P<.001) of reduced rCBF during acute hypoxia were identified (Blue regions in Figure 1). The first and largest encompassing regions such as the posterior cingulate cortex, visual regions of the occipital lobe, left cerebellum, brain stem, left temporal (insula cortex) and parietal lobe. The second occupied a region of the right temporal and parietal lobe. As previously, areas of increased rCBF were also found. These findings replicate and extend those found by Lawley et al. (2014) suggesting the neurovascular response to hypoxia differs at a regional level. The distribution of this response overlaps with regions generally characterised by a high resting state CBF. This may reflect either the enhanced susceptibility of these regions to hypoxia or a possible mechanism of reducing energy turnover to regulate supply and demand and protect those regions. This second interpretation would fit with animal-based models of hypoxic tolerance.

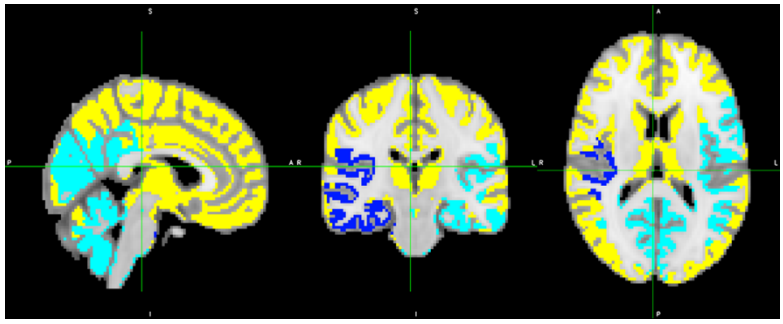

Figure 1. Cluster maps displaying significant rCBF reductions (blue regions) and increases (yellow regions) at the 3 hour time point in hypoxia compared to normoxia.

Conclusion: These results provide further insight into the spatial distribution of CBF disruption during hypoxia that may be related to accompanying cognitive deficits.

References

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