

Global cerebral metabolic oxygen consumption rate and cerebral blood flow can be measured reliably during oxygen inhalation

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Purpose: Global cerebral metabolic rate of oxygen (CMRO₂) and cerebral blood flow are important markers for brain function and brain state. Noninvasive measurements of these markers could be valuable tools for neuroscience and clinical practice. Recent years, it has been shown that CMRO₂ and CBF can be quantified using MRI techniques [1, 2]. Specifically, susceptometry-based oxymetry has been shown to be a quick way to quantify global cerebral metabolic changes. However, the robustness and reliability of this technique has not been tested during various physiological challenges. Quantifications of global cerebral metabolic changes during anaesthesia and different pathological conditions are of interest in neuroscience and clinical practice. This study investigated the feasibility and reliability of CMRO₂ and CBF quantifications during 40% oxygen inhalation.

Method: This study included 15 healthy volunteers (11 female and 4 male) ages ranging from 22 to 35 years old. All subjects gave written informed consent and the study was approved by the University of Nottingham Research Review board. Volunteers were scanned at baseline (medical air) and during 40% oxygen inhalation in the scanner. Physiological parameters including blood pressure, respiration and peripheral oxygen saturation were monitored. Scanning was done at 3T (Philips Achieva) using an 8-channel head coil. Data was acquired using a flow-compensated gradient echo sequence with slice thickness of 2mm, FOV 224 x 224 mm² and Ts of 5.53, 11.53, 17.53 and 23.53 ms. Image analysis and Fick's principle based CMRO₂ calculations were carried out as described previously using in-house Matlab routines [1]. Superior sagittal sinus was used for quantifications of venous oxygenation. ROIs were drawn by using FSLview (FMRIB, Oxford). Cerebral blood flow data was collected using QUASAR pulsed ASL sequence and was analyzed using EasyMRI software as described elsewhere [3]. Group statistical significance was tested by using paired T-test with significance level of p<0.05 and all results are illustrated in mean ± S.E.M.

Results: Susceptometry-based oxymetry demonstrated venous oxygenation in superior sagittal sinus 0.68 ± 0.01 (68 ± 1%) during medical air inhalation and 0.7 ± 0.01 (70 ± 1%) during 40% oxygen inhalation (Fig1). Grey matter cerebral blood flow was 43.3 ± 2.01 ml/100g/min and 44.4 ± 2.67 ml/100g/min during medical air and 40% oxygen inhalation, respectively. Calculated global cerebral metabolic rate of oxygen did not change following a 40% oxygen inhalation (1.11 ± 0.06 μmol/g/min and 1.12 ± 0.1 μmol/g/min during medical air and 40% oxygen inhalation, respectively (Fig2).

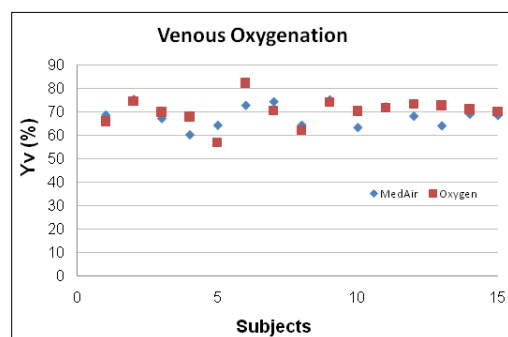


Fig 1. The mean SSS oxygenation measured by susceptometry-based oxymetry in 15 healthy young subjects during medical air and 40% oxygen inhalation.

Discussion: We have utilised the combination of ASL and susceptometry-based oxymetry in quantifications of CMRO₂ during medical air inhalations and its changes following 40% oxygen inhalation. We demonstrated that moderate amount of oxygen

does not change global cerebral blood flow and metabolism. Results of this study were well in line with previously reported venous oxygenation, CBF and global CMRO₂ values [1-3]. Moreover, this study was performed on larger group of subjects with reasonably good standard deviations.

Conclusion: In conclusion, this study demonstrates the reliable and robust measurement of global cerebral metabolic rate of oxygen using combinations of ASL and susceptometry-based oxymetry. Furthermore, this study show that moderate amount of oxygen does not change global CMRO₂ in healthy young subjects.

References:

1. Fan A.P, B.T., D.S.Bolar, B.R.Rosen, and E.Adalsteinsson. *Phase-based Regional Oxygen Metabolism (PROM) at 3T and feasibility at 7T.* in 18th ISMRM. 2010. Stockholm, Sweden.
2. Jain, V., M.C. Langham, and F.W. Wehrli, *MRI estimation of global brain oxygen consumption rate.* J Cereb Blood Flow Metab. **30**(9): p. 1598-607.
3. Petersen, E.T., K. Mouridsen, and X. Golay, *The QUASAR reproducibility study, Part II: Results from a multi-center Arterial Spin Labeling test-retest study.* Neuroimage. **49**(1): p. 104-13.

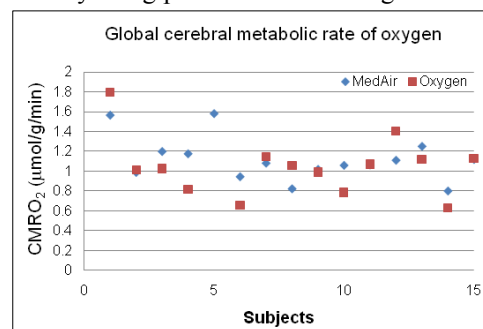


Fig 1. The global cerebral metabolic rate of oxygen calculated based on ASL CBF measurement and susceptometry-based oxymetry in 15 healthy young subjects during medical air and 40% oxygen inhalation.