MOBILE allows a follow-up of brain oxygen variations during a 100% O2 breathing

Florence Colliez1, Julie Magat1, Marta M Safronova1, Bénédicte F Jordan1, Thierry Duprez2, and Bernard Gallez1
1Louvain Drug Research Institute, Biomedical Magnetic Resonance Research Group, University of Louvain, Brussels, Belgium, 2Service de Radiologie, Cliniques universitaires Saint-Luc, Brussels, Belgium, 3Department of Radiology and Medical Imaging, Cliniques universitaires Saint-Luc, Brussels, Belgium

**Target audience:** Researchers interested in non-invasive brain oxygen modulation analysis and in non-invasive cerebral oxygenation mapping in a clinical setting.

**Purpose:** There is a critical need for dynamic, noninvasive, and repeatable methods for mapping and even monitoring brain oxygenation. Variations in T1 and T1* are potentially valuable MRI indices of changes in tumor oxygenation. ‘BOLD-MRI’ measures T2*, which is sensitive to the relative Hb/HbO2 ratio in vessels and provides information on vascular oxygenation1. T1 is more sensitive to dissolved oxygen which acts as a T1-shortening paramagnetic endogenous contrast agent that can be measured by a method known as ‘Oxygen enhanced MRI’2. We hereby (i) test the ability of ‘MOBILE’ (Mapping of Oxygen By Imaging Lipids relaxation Enhancement) - a method of oxygenation mapping based on changes in relaxation properties of the tissue lipids by exploiting the higher solubility of oxygen in lipids than in water3 - to map brain oxygenation in brain and cerebellum; (ii) evaluate the capability of MOBILE to detect an increase in tissue oxygen level on healthy volunteers submitted to a 100% O2 breathing challenge; and (iii) compare sensitivities of the ‘MOBILE’ and ‘Oxygen enhanced MRI’ techniques.

**Methods:** *Patient recruitment:* 18 healthy volunteers gave informed consent to participate in the study and to be submitted to a hyperoxic breathing challenge. We arbitrarily chose to obtain images of the supra-tentorial space in 10 of them, and of the posterior fossa (PF) in 8.

*Clinical MR experiments:* Imaging was performed on a clinical 3.0T MRI system (Achieva; Philips Medical System, Best, the Netherlands) with a transmit/receive head coil. One routine FLAIR sequence was acquired for all volunteers before performing the following investigational sequences: (1) ‘Oxygen enhanced MRI’: global T1 measurements were done with a Look Locker sequence (T1 TFE, T1 Turbo Field Echo sequence) applied during 10 seconds with TR/TE/flip angle/TFE/NSA= 3.467ms/1.45 ms/5°/10/1 to acquire one 20 mm thickness slice covering a FOV of 180x230 mm with a matrix size of 80² resulting in a voxel size of 3.91x5.08x20 mm. (2) ‘MOBILE’: to measure Lipids T1, the same sequence was used with the addition of a 90° SPIR pre-pulse (Spectral saturation by Inversion recovery) to spoil water signal with a BW of 300Hz centered on the water peak. 38 images averaged 30 times with similar metrics than previous acquisition were obtained for total acquisition time of 4 min.

*Examination protocol:* One set of 2 images (global T1 and Lipids T1) was acquired during air breathing (baseline) and 5 minutes after a switch to 100% O2 breathing. *Statistical analysis:* t-test was applied for every comparison.

**Results:** Parametric maps of R1 (R1=1/T1) were obtained for each sequence. ROIs were delineated by manual contouring on morphologic FLAIR images and thereafter overlaid on parametric maps. We observed a significant difference between WM and GM for both Global T1 and Lipids T1 with p=0.0002 and p<0.0001, respectively (t-test) (Figure 1).

Hyperoxic challenges were considered significant when we observed a relative change in Lipids R1 ≥ 0 within WM and/or GM for the supra-tentorial images and thereafter overlaid on parametric maps. We observed a significant difference between WM and GM for both Global T1 and Lipids T1 with p=0.0002 and p<0.0001, respectively (t-test) (Figure 1).

Hydrogen peroxide was considered significant when we observed a relative change in Lipids R1 ≥ 0 within WM and/or GM for the supra-tentorial images and thereafter overlaid on parametric maps. We observed a significant difference between WM and GM for both Global T1 and Lipids T1 with p=0.0002 and p<0.0001, respectively (t-test) (Figure 1).

**Discussion:** The ‘MOBILE’ sequence performed in a clinical setting hereby demonstrated ability to provide parametric mapping of Lipids R1 in both supra-tentorial space and cerebellum. Moreover, distinction between white matter and gray matter was obtained by calculating conventional Global T1 and Lipids T1 values. ‘MOBILE’ was able to detect an increase in WM and GM oxygen level induced by a 100% O2 breathing challenge whereas no significant increase in Global R1 has been observed. Although the responses to hyperoxia seem to be equivalent in the all brain (in terms of R1 variations), no significant variation has been observed in the posterior fossa structures after the 100% O2 breathing. This could be explained by the known different autoregulation dynamics between anterior and posterior circulations4.

**Conclusion:** ‘MOBILE’ is a suitable method to map oxygenation in healthy brain tissues with sufficient sensitivity to discriminate white matter from gray matter in the supra-tentorial space. Moreover, increase in oxygen level induced by a hyperoxic challenge can be monitored in brain by ‘MOBILE’ with a higher sensitivity than with ‘Oxygen enhanced MRI’.