Susceptibility Weighted Imaging (SWI) of Cerebral Physiology of Non-Human Primate during Carbogen Inhalation

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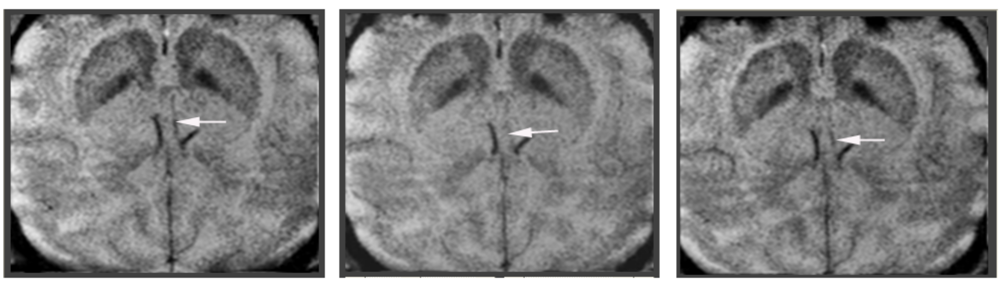
Introduction: The respiratory challenges have clinical importance in brain function including autoregulation and the rate of brain metabolism. Inhalation of carbogen increases cerebral blood flow by about 50% (1). Susceptibility weighted imaging (SWI) has the potential of producing high resolution venographic image by exploiting the magnetic susceptibility between deoxygenated venous blood and the surrounding tissue (1-4). The aim of this study was to assess cerebral venous blood oxygenation changes during inhalation of 100% O_2 and Carbogen (95% O_2 + 5% CO_2) by non-human primate using SWI at 3.0T.

Materials and Methods: Five healthy (4 female and one male) macaque monkeys with age ranging between 5 and 25yrs) were used in this study. All data were acquired on 3T Siemens Trio whole-body human MR systems (Siemens, Erlangen, Germany) with imaging parameters as follows:. TR/TE = 35/25ms, flip angle = 20º , Bandwith = 70Hz/pixel, matrix = 192 x 192, FOV= 96 x 96 mm^2, 36 slice to cover the lateral ventricular level, and slice thickness of 1.0mm An 8-channel array head coil was used for all the measurements. The data was analyzed using SPIN software. The phase images were high-pass filtered and SWI magnitude images were created. The minimum intensity projection (mIP) generated over every 5 slices to get a 5mm thick SWI venographic image. The scans were repeated four times in each animal over 3 month period.

Results: Our result in the non-human primate shows the venous architecture slightly attenuated during the inhalation of carbogen on the SWI mIP venogram as indicated by the white arrow in figure 1. The alteration of the concentration of deoxyhemoglobin in the veins, causes change in the signal intensity indicating that the oxygenation level in the brain can be clearly seen on SWI in all animals. As shown in figure 1, we compared the scan with normal breathing of 100% O_2 as a baseline, and the time during the breathing of carbogen (5% CO_2 + 95% air) and a few minutes after inhalation carbogen with another normal breathing of 100% O_2. The venous vasculature that is not visible on usual conventional imaging is shown to be visible in the SWI scanned image.



Pre **CO2** **Post**

Figure1. Axial SWI minimum intensity Projection of A) normal breathing of O2, B) carbogen inhalation, and C) normal O2 breathing few minutes after carbogen. There was a slight decrease of signal intensity during carbogen inhalation in all animals. The different response is due to the alteration in oxygenation level.

Discussion and Conclusion: The processed SWI results at 3T in this study demonstrate that cerebral blood oxygenation changes during respiratory challenge can be detected and visualized. The SWI venogram reveals the oxygenation change in the various sizes of veins that is not related to neuronal activity as compare to BLOD fMRI. Our data reveal that during the inhalation of carbogen blood flow increases significantly with a range of 59~71% in different feeding arteries as well as venous sinus that transport more blood to compensate decreased oxygen saturation without increase of oxygen consumption. This study emphasizes that venous blood oxygenation is strongly influenced by CBF changes due to the modulation of CO_2 during respiratory challenge, which can be directly visualized on SWI.

References: 1. Sadlacik et al Neuroimage (2008); 2. Haacke EM et al MRM (2004); 3. Haacke EM et al JMRI (2009), 4. Pfefferbaum et al Neuroimage (2009)