Vessel contrast in Susceptibility Weigthed Imaging (SWI) under inhalated anesthesia with different oxygen pressure

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Introduction

Susceptibility weighted imaging (SWI) has been used to depict the structure of the cerebral vascular system [1, 2]. However, it has not been much extended in small animal imaging. During the MRI exam, animals are anaesthetized, which makes the venous contrast vary not only according to the depth of anaesthesia [3], but also to the oxygen pressure in the supplied gas when using inhaled anaesthesia. SWI signal is based on the tissue susceptibility differences, which are related to blood oxygenation [4], and therefore using anaesthetics along with pure oxygen for animal sedation can lead to a loss of contrast of cerebral veins in SWI.
The purpose of this study was to investigate how the oxygen pressure in the supplied gas affects the venous contrast in SWI in order to study the microvasculature of the rat brain.

Materials and Methods

A 7T Bruker Biospec 70/20 scanner was used to obtain phase images of SWI, with a fully flow-compensated, three-dimensional gradient echo sequence (3D-GEFC, TR =35 ms, TE = 14 ms, FA = 18°, matrix= 256×256×96 and voxel size = 0.117×0.117×0.25 mm), using a rat head surface array coil.
A male Wistar rat weighting 300 grams was anaesthetized with sevofluorane (4% for induction and 1% for maintenance) while temperature, respiration rate (RR) and saturation of peripheral oxygen (SpO2) were monitored. During the studies, the animal was heated with a water blanket to maintain its temperature at 37º (low temperatures causes a vasoconstriction).The oxygen pressure in the supplied gas was varied (100%, 40%, 30%, 20%, 15% and 12%) and controlled with a gas mixer device. One image was acquired at each concentration after 15 minutes of stabilization.
The multi-channel phase images were combined using a weighted average [5], and phase wraps and background field variations were removed with a 3D algorithm followed by high pass filtering according to [6]. SWI images were obtained by combining magnitude data with a phase mask [1].The same profile was traced through a vessel over the filtered phase images.

Results

During the experiments, the temperature was stable around 37ºC. Mean of SpO2 during each SWI scan decreased with the oxygen pressure supplied, while RR increased (Figure 1).
Figure 2 depicts how phase difference between a principal vein and surrounding tissue varies with oxygen saturation, though not linearly.
Comparison of SWI images at different oxygen pressure is shown in figure 3. Zoomed images illustrate the contrast improvement in the smallest vessels with less supplied oxygen.

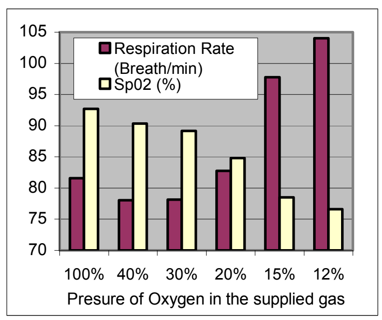

Fig. 1. Variation of respiration rate and saturation of peripheral oxygen

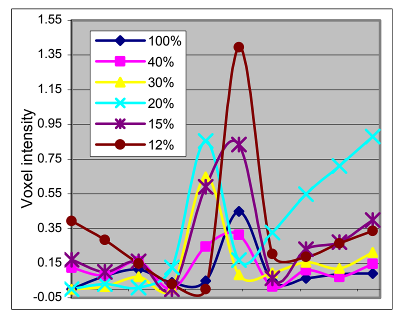

Fig. 2. Phase value on a profile through a main vessel

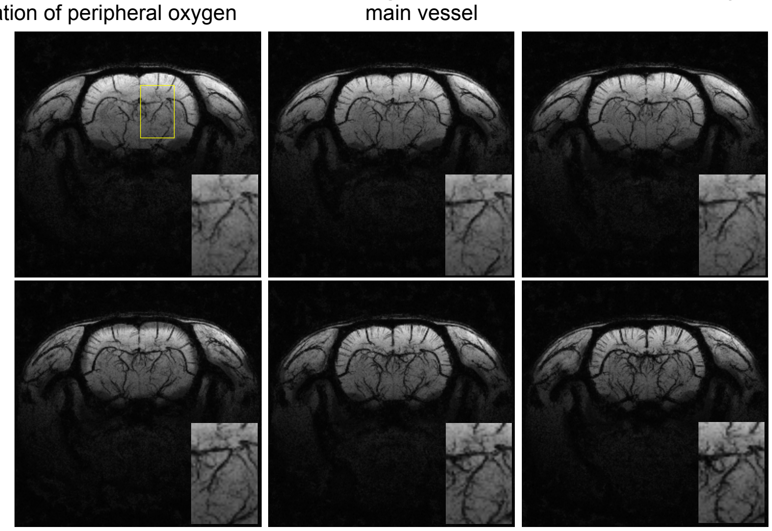

Fig. 3. Minimum intensity projection of 1.25 mm thick on the 3D SWI and zoom over an area at different pressures of oxygen. From left to right and top to bottom 100%, 40%, 30%, 20%, 15% and 12%.

Discussion and Conclusion

According to the theory, delineation of microvasculature in SWI image improves whit low oxygen saturation. However, decreasing the pressure of oxygen in the supplied gas causes RR to increase; which might be undesirable in some experiments. Another point against decreasing the supplied oxygen in excess is that pathologic areas may not be distinguished when studying vascular failure, for example in an ischemic accident. If phase differences are to be measured in order to compare different studies (e.g. pre and post trauma), special caution must be taken with the gas mixture provided.
Depending on the experiment, the best oxygen pressure should be studied. However, under general conditions, 20% of oxygen allows good delineation of microvasculature without inducing hyperventilation.

References

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