Contrast optimisation for SWI venography at 7T

M. Barth[1,2], and P. J. Koopmans[1]

[1]F.C. Donders Centre for Cognitive Neuroimaging, Radboud University, Nijmegen, Netherlands, [2]E.L. Hahn Institute for Magnetic Resonance Imaging, University Duisburg-Essen, Essen, Germany

Introduction

Depiction of the venous vasculature of the human brain is important for clinical purposes [1] as well as functional MRI in order to classify venous contribution [2]. MR venography based upon susceptibility weighted imaging (SWI) has been shown to depict venous vasculature with very high detail [3]. While higher field strengths are clearly beneficial for SWI venography [4] no detailed study has been performed to optimize the echo time at 7 Tesla for this purpose.

Methods

All experiments were performed on a whole body MRI scanner at field strengths of 7T (Magnetom 7T, Siemens, Erlangen, Germany). In order to estimate T_2*, a multi (twelve) echo version of the SWI sequence was used in four subjects with TE ranging from 5 ms to 60 ms (TR = 70 ms), interecho delay was 5 ms (BW 210 Hz/px). T_2* values of gray matter (GM), white matter (WM) and venous blood were obtained using respective ROIs using a non-linear fit routine (curvefit) implemented in IDL (Creaso, Germany). All echoes were used in the fit procedure except for estimating the short T_2* of venous blood in the sagittal sinus where the first five echoes were used. By using ROIs containing veins perpendicular to B_0 and ROIs of surrounding tissue we estimated the contrast in dependence of TE. High resolution SWI data sets were acquired using the following parameters: TR = 22 ms, TE = 15 ms, $\alpha = 15°$, BW = 120 Hz/pixel, acquisition time = 13:30 min, acceleration factor =2, 72 slices. A transverse orientation with a resolution of 0.27x0.27x1.5 mm3 (109 nl) was used.

Results and Discussion

In our relaxation time measurements at 7 Tesla, T_2* values of 32.9 ± 2.3 ms (occipital GM), 27.7 ± 4.3 ms (occipital WM outside the optical tract), 7.4 ± 1.4 ms (venous blood within the sagittal sinus) were found which are in excellent agreement with literature values [5]. In order to estimate T_2* related contrast we make use of $C(TE) = \exp(-TE/T_{2T}^*) - \exp(-TE/T_{2B}^*)$ and insert the T_2* for tissue ($T_{2\,T}$*) and blood ($T_{2\,B}$*) obtained in this study. For contrast simulations at B_0 of 1.5T and 3T literature values were used [5-10]. The T_2* value of GM was used for tissue to obtain optimum T_2* contrast for intracortical veins.

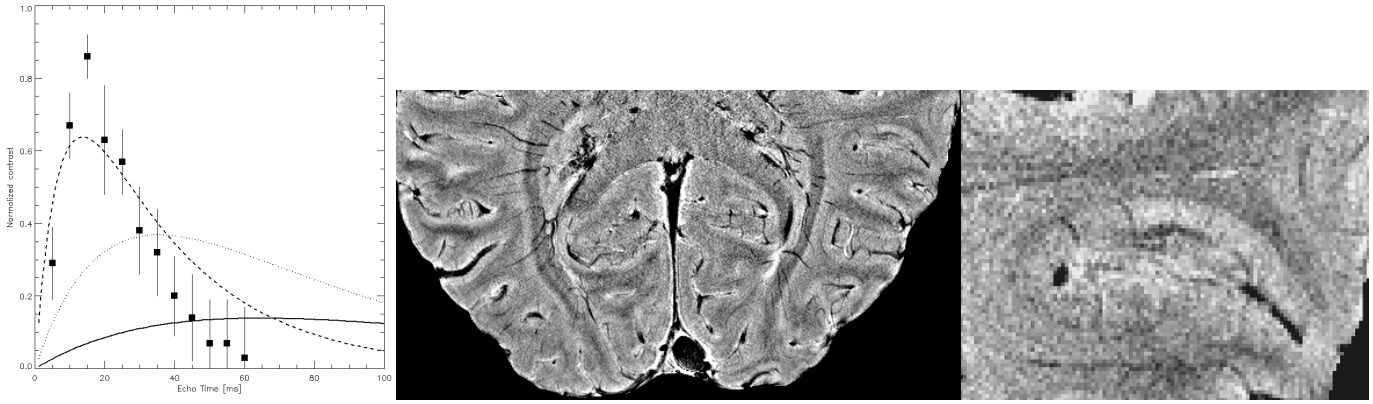

Fig. 1: (a) Simulated normalised contrast plotted versus TE for the three field strengths and measured contrast for veins perpendicular to B_0. (b) magnitude image of a single slice acquired at 7 T using a TE of 15 ms. (c) To appreciate the small details a zoomed section is shown.

In Fig. 1 the contrast normalised to the GM signal at TE = 20 ms is plotted versus TE for the three field strengths (dashed line – 7T; dotted line – 3T, the straight line – 1.5T). Optimum contrast can be estimated to occur at an echo time of around 64 ms (1.5 T), 35 ms (3 T) and 14 ms (7 T).Compared to 1.5 T, the contrast at the echo time where the maximum contrast occurs (without accounting for noise) is increased by a factor of 2.7 at 3 T and 4.6 at 7 T, respectively. We compared these simulations to the measured contrast between veins perpendicular to B_0 and surrounding tissue at 7 Tesla. These values are plotted as squares (± standard deviation over subjects) in Fig. 1a. The echo time where maximum contrast at 7 T occurs (i.e. at 15 ms) corresponds very well to the one found in the simulations. Accordingly, in the SWI venography measurements an echo time of 15 ms was used to obtain optimum contrast for veins. Note, that the absolute value of the normalised contrast was different due to additional dephasing effects that are not accounted for in the simulations. In Fig. 1b the magnitude image of a single slice out of an SWI dataset acquired at 7 T using a TE of 15 ms is shown. To appreciate the small details a zoomed section is shown in Fig. 1c. Note the high contrast even for very small anatomical structures visible.

References

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