Evaluation of Contrast Mechanisms in the Substantia Nigra, Red Nucleus and Adjacent Brain Stem structures at 7T

P. A. Wassenaar[1], G. Mihai[1], A. M. Abduljalil[1], D. W. Chakeres[1], M. V. Knopp[1], and P. Schmalbrock[1]

[1]Department of Radiology, The Ohio State University, Columbus, OH, United States

Introduction

In Parkinson's disease, imaging of the brainstem with high spatial resolution and improved contrast may advance diagnosis. The brainstem contains a number of structures that are highly vascularized [1], and that also have high iron content [2]. Both venous deoxyhemoglobin and parenchymal iron will profoundly affect MR contrast especially at ultrahigh field strength. The purpose of this study was to evaluate the T1, T2*, and phase contrast properties of mesencephalon structures, specifically the substantia nigra (SN), the medial lemniscus (ML), the red nucleus (RN) and the parietotemporopontine tract (PT). This information may help elucidate the origin of contrast mechanisms and perhaps allow differentiating effects from vasculature and tissue iron, thus aiding diagnosis and increasing knowledge about disease mechanisms.

Method

Ten healthy subjects were studied at 7T (Philips Achieva 7.0T, Cleveland, OH) using a transmit/receive head coil and a 3D inversion recovery prepared turbo dual gradient echo sequence (IR-dTFE: TI=1360ms, TR/TE/flip angle=13ms/2.1 and 10.5ms/8°, shot interval 2800ms, FOV 230mm, 512 matrix, 100 slices with a reconstructed voxel size of 0.45x0.45x0.8mm). Both magnitude and high pass filtered phase images were reconstructed from these data. For assessment of contrast behavior, additional IR-TFE images with TI 140-2650ms, TR3.3-13ms, and single echo data with TE=1.7-6.0ms were collected. Images with different TI were fitted with A+Bexp(-TI/T1), and images with different TE were used to estimate T2*.

Results

Fig. 1 shows a slice through the middle part of the mesencephalon. The first echo depicts the red nucleus and substantia nigra with high signal isointense with the PT; only the dense white matter fiber bundle between the nuclei has low signal. This contrast is unusual, as the RN and SN commonly are seen hypointense. On the second echo and its corresponding phase image, the RN and SN are dark, due to high vascular density and tissue iron. T1 dependence of image contrast in the mesencephalon is shown in Fig. 2 (T2* effects are minimized in these images by TE=1.7ms). Note the contrast inversion between white matter tracts and nuclei for TI=350 and 850ms. The nuclei have shortest T2*≈10ms, whereas T2* is longer in the fiber tracts (T2*≈15ms), consistent with prior work [3].

Fig 1: IR-dTFE magnitude images at TE=2.1, TE10.5 and long TE phase image

Conclusion

Ultra high field inversion recovery prepared turbo field echo (IR-TFE) imaging has a wide range of contrast options for high resolution imaging of the mesencephalon, making 7T a promising tool for assessment of brain stem disorders such as infarcts, and Parkinson's disease. The interesting T1 contrast between mesencephalon structures, which may be attributed to tissue iron, can only be observed with the shortest TE, because even for TE≈5ms, T2* effects will dominate. Comparisons between phase images and India ink stained sections suggest that phase images may predominantly represent vascular density, however, further studies are needed to assess this hypothesis.

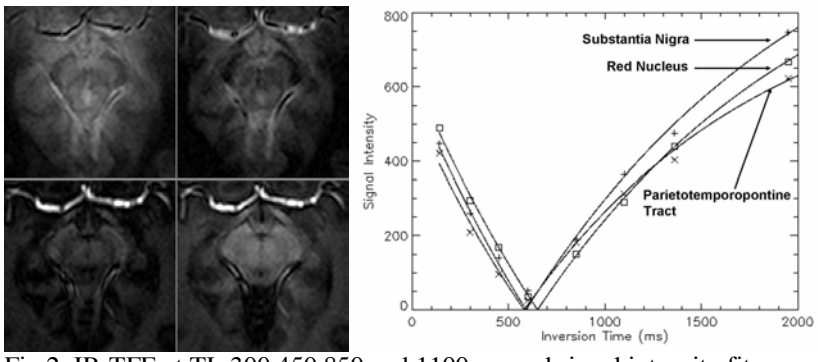

Fig 2: IR-TFE at TI=300,450,850 and 1100ms, and signal intensity fits through manually drawn ROIs in the listed regions

References

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[3] Truong, et al, MRM 55:1390-1395, 2006