Neuromelanin MR Imaging: Detection of Locus Coeruleus Using T1 Weighted Gradient Echo Imaging

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INTRODUCTION

Neuromelanin pigment in locus coeruleus (LC) generates image contrast that decreases as neurodegeneration (loss of neuromelanin) progresses in some pathological conditions such as Parkinson's disease. Locus coeruleus is a very small rod-shaped structure (approximately 2-mm wide and 15-mm long) located in the pontine tegmentum (dorsal pons) along the 4th ventricle. Locus coeruleus is challenging to image due to its location, dimension and contrast with surroundings and requires a high spatial resolution approach. Hence, the development and optimization of such an approach is of great value as non-invasive neuromelanin imaging offers a means to study disease pathogenesis in vivo. Turbo spin echo (TSE) imaging has been used to generate neuromelanin contrast in recent years [1]. TSE imaging with magnetization-transfer contrast (MTC) was also attempted for increasing paramagnetic contrast [2]. However, TSE imaging with MTC increases specific absorption rate (SAR), which would be more problematic at high fields. In this study, we examine a T1-weighted 2D gradient echo (GE) imaging with MTC to image LC with the improved contrast afforded by MTC while a reduced SAR is sought.

METHODS AND MATERIALS

All experiments were performed on a 3 T scanner (TRIO, Siemens Medical Solutions, Malvern, PA) using a body coil for transmission and a 12-channel head coil for signal reception. Locus coeruleus of 3 control subjects and 2 patients with Parkinson's disease was imaged using a 2D TSE sequence and a 2D GE sequence with MTC for comparison. Imaging parameters of TSE are as follows: TE/TR= 14/600 ms, 16 slices, 178x200 mm FOV, 456x512 imaging matrix, 0.4x0.4x2.5 mm resolution, 6 averages, 2 echo train length, and 158 Hz/pixel receiver bandwidth (total scan time: 13 min 41 sec). Those of GRE are as follows: TE/TR= 2.91/259 ms, 11 slices, 188x200 mm FOV, 480x512 imaging matrix, 0.4x0.4x3 mm resolution, 6 averages, 70^0 flip angle, MTC preparation pulse, and 337 Hz/pixel receiver bandwidth (total scan time: 12 min 26 sec). Since the LC is very small (and only a small number of pixels in a section is contained) and has little contrast relative to the surrounding tissue, 6 averages were performed to obtain an appreciable signal.

RESULTS AND DISCUSSIONS

Fig. 1 shows two LC images, one with MTC (bottom image) and the other without (top image). All other imaging protocols are the same. A decrease in contrast between gray and white matter was observed, resulting from the signal attenuation caused by MTC. There was also differential signal attenuations in LC and surrounding pons, producing an increased contrast-to-noise ratio (CNR) between the two regions (LC/pons/CNR= 616/581/3.3 (without MTC), 402/320/8.2 (with MTC)). This increase in contrast can be seen more readily in enlarged images (Fig. 1b and e) and histograms (Fig. 1c and f) of the region of interest (ROI, blue rectangle). Fig. 2 shows LC images obtained by using TSE imaging (right) and GE imaging with MTC (left) from 5 participants. To better demonstrate and make comparison, each image's brightness and contrast were adjusted by windowing. 10~12 pixels from LC were selected and used to calculate CNR between LC and surrounding pons. Numbers at a lower right-hand corner in each image indicate CNR. GE imaging with MTC shows better CNR overall, although this effect is pronounced in some subjects and absent in 2. Pulsation of the 4th ventricle may cause artifact, compounding the difficulty of imaging LC. Motion artifacts can easily mis-register the ROI by pixels, which is especially likely to occur in patients with neurodegenerative diseases.

Locus Coeruleus typically shows little signal difference with its surroundings, making it difficult to see in MR images. Optimized gradient-echo imaging with MTC may be useful for the imaging of LC by enhancing the paramagnetic contrast, contributing to pathogenesis studies of neurodegenerative diseases.

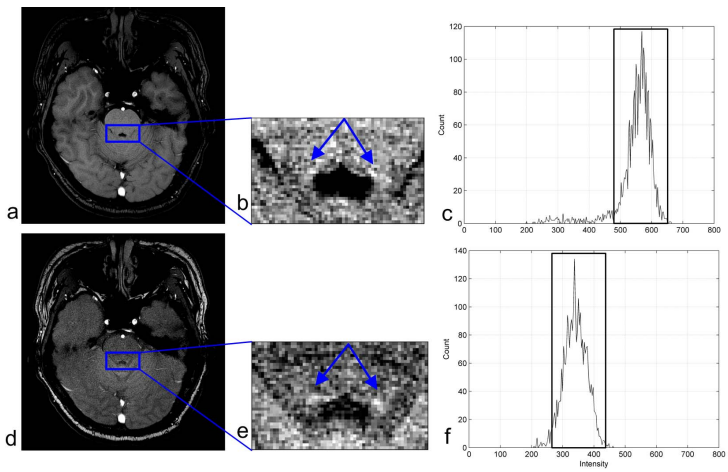

Fig. 1. LC (two bright dots in a blue rectangle) images with (bottom) and without (top) MTC

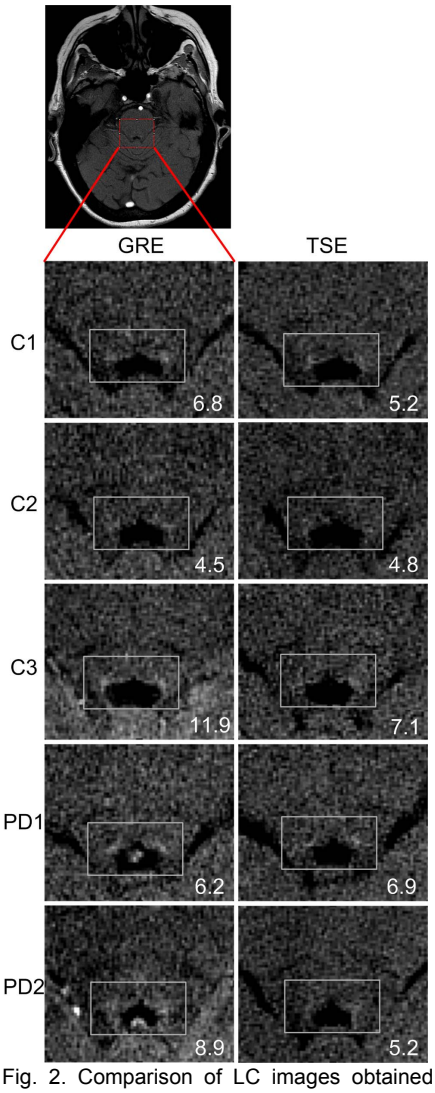

Fig. 2. Comparison of LC images obtained from 5 participants (C1~3 and PD1~2), acquired with TSE imaging vs. GE imaging with MTC. CNR is indicated at a lower right-hand corner of image.

REFERENCES

[1] NeuroReport 2006;17:1215-1218. [2] Movement Disorders 2011;26:1633-1638.