Slower Transverse Relaxation in the Dominant Hemisphere

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Introduction

Most of time, our two cerebral hemispheres have different functions and usually one side dominates over the other on some specific functions. Significant structural difference has been noticed between the two hemispheres, however, it is still not clear whether there is any difference in the brain tissue relaxation time between the two hemispheres. The characterization of hemispheric symmetry of transverse relaxation rate, R_2 ($1/T_2$), in a specific anatomic structure in the normal human brain is important baseline information for clinical applications of T_2-weighted imaging and quantitative parametric mapping. This is particularly important in the study of one side dominant neurological disorders and diseases, such as unilateral Parkinson's disease and amyotrophic lateral sclerosis. To address this issue, we established a detailed R_2 distribution in a large normal human brain cohort (a total of 102) at 3.0 T.

Methods

Human Subjects: One hundred and two healthy volunteers (46 males and 56 females, 48.5 ± 22.1 years, ranging from 9 to 83 years, 8 left handed) participated in the study. There was no significant age distribution difference between the two gender groups (p = .71). Participants had no history of neurologic or psychiatric diseases. All subjects and parents of the subjects under 18 years old gave informed written consent prior to participation.

MRI protocol: A fast spin-echo sequence was used to scan the whole brain on a Bruker MedSpec S300 3.0 T system with a TEM head coil for RF transmission and reception. Manual shimming at the mid-brain, hippocampus and basal ganglia was carefully performed. A series of T_2-weighted images were obtained using a multi spin-echo sequence (TR / TE / FA = 4000 ms / 11.8 ms / 180º, bandwidth = 80 kHz, 9 echoes, 20 2.5-cm-thick axial slices with no gap between slices, FOV = 25 × 25 cm^2, matrix = 256 × 192) for R_2 measurement.

Data processing and analysis: R_2 maps were generated using linear regression with qMRI, an in-house developed software in Interactive Data Language. For voxel-based analysis, the R_2 maps from all the subjects were normalized to the Montreal Neurological Institute brain template [1] using SPM2 [2]. The resultant resolution of the R_2 map was 1 × 1 × 1 mm^3 and then smoothed with a 2.5 × 2.5 × 2.5 mm^3 Gaussian kernel.

Results

The correlation of R_2 with age was analyzed on all the subjects and also within the two gender groups, and was significant (see Figs. 1-2). The effect of gender was analyzed with a general linear model with age as a covariate. There was no significant gender effect on R_2. The R_2 in the male brain basal ganglia tended to be higher than the female (0.11-0.19 s^{-1}), however, it is not significant ($t < 1$, $p > .32$). Paired t-test and correlation analyses showed that the R_2 in the dominant hemisphere basal ganglia is lower than the other side. ($t = 2.30$, $p = 0.024$; Fig. 3).

Discussion

The lower R_2 in the dominant cerebral hemisphere was particularly interesting because heavier myelination and iron deposition are known to correlate with shortening T_2. The data in Fig. 3 are likely to indicate a less iron deposition in the dominant hemisphere since basal ganglia is known to have high iron concentration. This study showed strong age dependence of R_2 in basal ganglia. It is also known that brain tissue iron deposition is correlated with aging [3]. These findings suggest that the aging process and the dominance of hemisphere could interact and modulate the overall and specific brain T_2 relaxation distributions. This study provides the largest and most comprehensive normative T_2 data set at 3.0 T MRI system so far, which will benefit future clinical trials using T_2 mapping.

References

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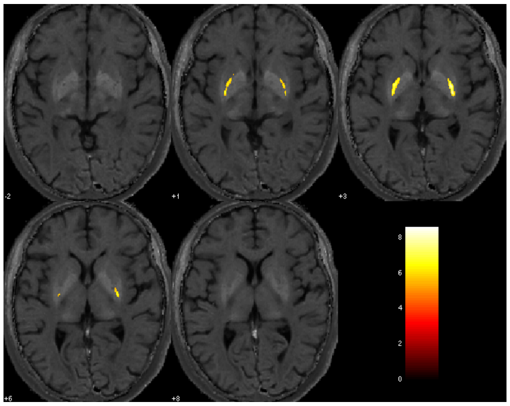

Figure 1. Strong positive correlation of R_2 with age in bilateral basal ganglia (FWE corrected $p < .05$, overlaid on the R_2 map of a 51-year-old right-handed woman).

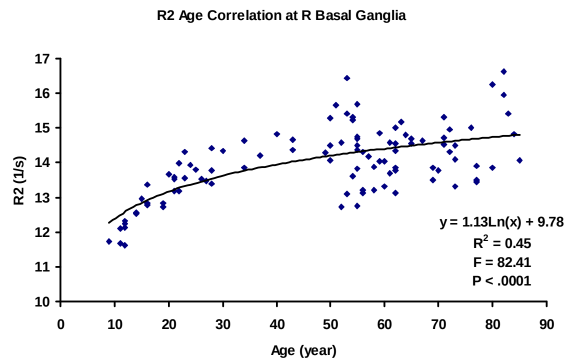

Figure 2. The age dependence of R_2 at right basal ganglia ($R^2 = .45$, $F = 82.41$, $p < .0001$).

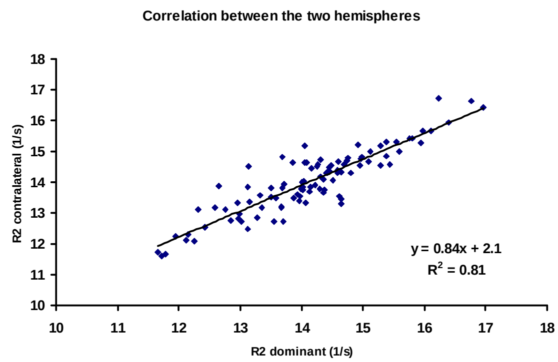

Figure 3. The R_2 in dominant hemisphere basal ganglia is lower than contralateral hemisphere. ($R^2 = .81$, $F = 428.98$, $p < .0001$).