Evaluation of Brain Iron In Vivo with Susceptibility Weighted Imaging

X. Xu[1], Q. Wang[1], M. Zhang[1], and G. Cao[2]

[1]Radiology, First Affiliated Hospital, School of Medicine, Zhejiang University, Hangzhou, China, People's Republic of, [2]GE Healthcare China

Introduction

Susceptibility-weighted imaging (SWI) has been used to describe data acquisition and reconstruction methods that enhance subtle differences in subvoxel magnetic inhomogeneities [1]. As a paramagnetic substance, iron deposited in the brain will cause subvoxel magnetic inhomogeneities, which leads to a negative phase relative to the surrounding parenchyma. In general, the higher the iron content, the higher were subvoxel magnetic inhomogeneities and the greater were the resultant phase shifts. Therefore, SWI could be used to detect minor iron concentration differences in the brain. The phase images tend to make these differences even more apparent due to the fact that high iron content increases the observed phase shift. We hypothesized that the phase shifts should vary linearly with brain iron concentration, and SWI has potential for quantifying brain iron in vivo.

Materials and Methods

Fifty-nine healthy adult volunteers were studied with a GE 1.5T Signa EXCITE II scanner. The subjects ranged in age from 30 to 78 years (mean=48.3, SD=11.4). All subjects were imaged with the following 3D GRE sequence: TR = 51ms, TE =38ms, FA = 20°, slice thickness = 2mm, FOV = 24cm, and matrix size = 256×256. The slab contained 28 continuous slices, and the slab center was superposed on the anterior and posterior commissure line (AC-PC line). A spatial high-pass filter was applied to the initial phase image to remove slowly varying phase shifts caused by background static field gradients. The phase shifts were measured on the “corrected” phase images in six subcortical structures. The third and fourth slices above the AC-PC line were used to obtain the data of the globus pallidus (GP), putamen (PU), caudate (CA), thalamus (TH) and frontal white matter (FWM), and the second and third slice inferior to the AC-PC line were used to obtain the data of the substantia nigra (SN) and red nucleus (RN). All the data were obtained from contiguous pairs of slice. Regional phase shifts were compared with published brain iron concentration (Table 1) [2] by linearly correlation analysis.

Results

	Iron Concentration (mg Iron/100 g Wet Brain)	Observed Phase shifts
FWM	4.24	-0.0025±0.0114
TH	4.76	-0.0100±0.0093
CA	9.28	-0.1055±0.0290
PU	13.32	-0.0451±0.0261
SN	18.46	-0.0905±0.0243
RN	19.48	-0.0949±0.0447
GP	21.3	-0.1089±0.0277

Table 1. The distribution of iron and phase shifts in different parts of the human brian.

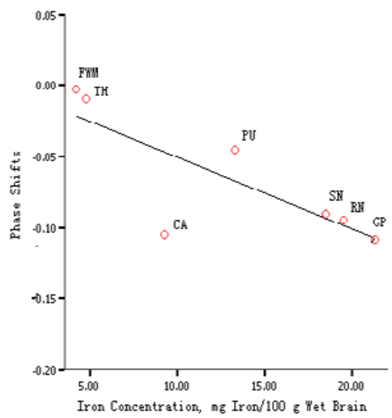

Fig 1. Scatter plots of phase shift vs. iron concentration for the various anatomic regions. The correlation is generally good (r= 0.798, P = 0.031)

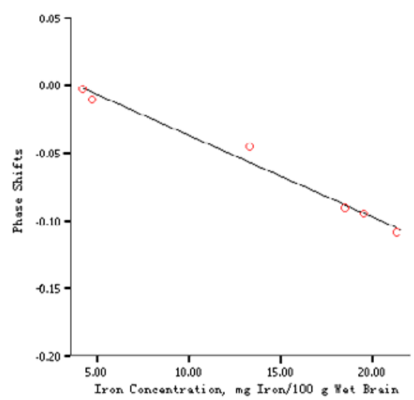

Fig 2.Scatter plots of phase shift vs. iron concentration for the various anatomic regions except CA. The correlation is virtually linear (r = 0.991, P<0.001).

Conclusion

Although somewhat over-estimate the iron concentration in caudate, the phase shifts in gradient-echo sequence can reflect iron-induced differences in brain tissue susceptibility in the human brain. SWI may be useful for estimating the amount of iron deposits in the brain in vivo.

Reference

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[2]. Hallgren B, Sourander P. J Neurochem 1958; 3: 41-51.

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