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ORIGINAL ARTICLE

A diffusional kurtosis imaging study of idiopathic generalized epilepsy with unilateral interictal epileptiform discharges in children

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KEYWORDS
Diffusional kurtosis imaging;
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Summary
Background and purpose: To investigate brain abnormalities in children with a clinical diagnosis of idiopathic generalized epilepsy (IGE) and unilateral interictal epileptiform discharges (IED) demonstrated on electroencephalography (EEG) by diffusional kurtosis imaging (DKI).
Materials and methods: DKI images were obtained from 18 patients ($n = 9$ each in the left and right hemispheres). Fractional anisotropy (FA), mean diffusivity (MD), and mean kurtosis (MK) maps were estimated through voxel-based analyses, and compared with 18 normal controls matched for age and sex.
Results: In the left side group, the significant differences of FA were in the left fusiform gyrus and occipital lobe of the white matter (WM). The significant differences of MD were in the left pons. The significant differences of MK were in the anterior cingulate gyrus, limbic lobe,

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gray matter (GM) and WM of the right cerebrum. In the right side group, the significant differences of FA were in the WM of the left cerebrum. MD identified differences in the frontal, temporal, occipital, and parietal lobes of both hemispheres, especially in the limbic system, fusiform gyrus, uncus, and parahippocampal gyrus. The significant differences of MK were in the GM of the right cerebrum, particularly in the rolandic operculum and frontal lobe.
Conclusions: DKI is sensitive for the detection of diffusion abnormalities in both WM and GM of IGE in children. Secondary brain abnormalities may exist in regions outside the unilateral epileptogenic zone through the limbic epileptic network, and can be detected by DKI indices FA, MD and MK.

Introduction

Epilepsy is a brain disorder involving recurrent and spontaneous interruptions of normal brain activity, called epileptic seizures. Idiopathic generalized epilepsy (IGE) is defined by recurrent generalized seizures, such as absence, myoclonic and generalized tonic—clonic seizures [1], and constitutes a heterogeneous group of seizure syndromes usually beginning in childhood and adolescence. Routine magnetic resonance imaging (MRI) is normal in IGE individuals [2]. However, quantitative neuroimaging methods have identified several regional abnormalities [3,4].

Diffusion tensor imaging (DTI) has played a significant role in understanding changes in tissue architecture, especially in cerebral white matter (WM). Recently, diffusion kurtosis imaging (DKI), an extension to DTI has been shown to exhibit enhanced sensitivity to microstructural changes in comparison with the conventional DTI [5—8]. Moreover, the kurtosis coefficients provide information on microstructural integrity in both WM and gray matter (GM) and can handle the situation of evaluating crossing fibers [6]. Thus, DKI can potentially improve the sensitivity and specificity of abnormal neural tissue characterization.

Only a few studies have reported the use of DKI in children with IGE [9,10]. We continued and pursued further in regard to our previous study [10], performing the whole-brain voxel-based analyses and investigating diffusional kurtosis indices in IGE children with unilateral interictal epileptiform discharges (IED), located in the left or right hemisphere confirmed by electroencephalography (EEG). Results were compared with normal controls (NC). The purpose of this investigation was to comprehensively characterize the distribution of WM and GM abnormalities in IGE children with unilateral IED. We postulated the presence of significant abnormalities in both cerebral WM and GM in IGE with unilateral IED that would not only affect regions ipsilateral to the side of seizure onset, but also involve the contralateral side.

Materials and methods

Subjects

We studied 18 consecutive IGE children with unilateral IED ($n = 9$ each in the left and right hemispheres) diagnosed by clinical and EEG or 24-hour video EEG. The 9 children with left IED (median age 8.27 ± 2.08 years; range 5.3—12.1; 5 girls) were compared with 18 age- and sex-matched children in the NC1 group (median age 8.34 ± 2.04 years; range 4.8—12.6 years; 9 girls). The 9 children with right IED (median age 6.50 ± 3.43 years; range 3.3—12.6; 4 girls) were compared with 18 age- and sex-matched children in the NC2 group (median age 6.91 ± 2.47 years; range 3.8—12.6; 8 girls).

The study received the approval by the Research Ethics Board in our hospital, and written informed consent was obtained from the custodians of all children. The recruitment criteria for the case group were clinically diagnosed IGE with normal conventional MRI, unilateral IED on EEG or 24-hour video EEG, no other neurological disorders and without febrile seizures. Eighteen age-matched children were recruited as the NC for each study group. All NC children have no record of a neurological disorder or brain injury and with normal conventional MRI findings.

Imaging protocol

The imaging protocols and parameters of the sequences are described elsewhere [10]. Data were acquired on a 3.0-T scanner (Signa, General Electric Medical Systems, Milwaukee, WI) using an eight-channel phased array coil. Diffusion-weighted imaging (DWI) with three b-values (0, 1250, and 2500 s/mm^2) and diffusion-encoding vectors along 25 non-parallel directions for each nonzero b-value were acquired. DWI, whole-brain T1-weighted magnetization-prepared rapid gradient echo (MPRAGE), T_2-weighted fluid-attenuated inversion-recovery (FLAIR) and sagittal fast spin-echo (FSE) sequences were used. The DWI parameters were TR/TE, 14000/76.9 ms; slice thickness, 2.5 mm; field of view (FOV), 24×16.8 cm^2; matrix, 96×96; one NEX. Whole-brain MPRAGE images were acquired with: TI, 450 ms; TR/TE, 713/2.2 ms; slice thickness, 1 mm; FOV, 24×24 cm^2; matrix, 320×256; one NEX; flip angle, 15°. T_2-weighted FLAIR imaging implemented the following parameters: TR/TE, 8002/153.9 ms; slice thickness, 5 mm; FOV 24×24 cm^2; matrix, 320×192; one NEX. Sagittal fast spin-echo (FSE) images were acquired with: TR/TE, 2560/116.6 ms; slice thickness, 3 mm; FOV, 24×24 cm^2, matrix, 384×224; two NEX.

Data analysis

The data analysis including preprocessing and normalization is described elsewhere [10]. In preprocessing, we first corrected raw DWI data distortion induced by eddy-current