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Research article

Application of diffusion tensor imaging in AIDS patients with brain opportunistic diseases: A comparative study of tuberculosis and toxoplasmosis☆

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Abstract

Objective: This paper aims to discuss the diagnostic value of quantitative DTI on AIDS patients with brain tuberculosis or toxoplasmosis.
Materials and methods: 22 subjects (12 with brain tuberculosis and 10 with toxoplasmosis) were recruited, who underwent routine MRI, T1WI-CE and DTI imaging sequence. The morphological characteristics of lesions were observed, and FA and ADC values of the solid areas, edematous areas and the contralateral normal areas of the lesions were calculated. Results were compared by one-way ANOVA and independent sample *t*-test. The TB diagnosis efficiency of these two values was analyzed by ROC curve.
Results: ADC and FA values were detected with significant differences among the three regions between subjects with brain tuberculosis and subjects with toxoplasmosis ($P < 0.05$). Statistically significant difference was recorded between solid and edematous areas and contralateral areas in ADC and FA values ($P < 0.05$). And so was between the solid areas and edema areas in either group. Moreover, the FA values of the solid areas between two groups also presented statistically significant difference ($P < 0.01$). ROC curve of TB showed the AUC of FA value was larger than that of ADC value (0.914 vs. 0.715, respectively, $P < 0.05$). DTT imaging showed infiltrative changes of white matter fibers in the lesion areas.
Conclusions: Quantitative DTI is valuable for diagnosis and differential diagnosis of patients with AIDS-associated infections, and also could provide references for clinical physicians for proper medications. The quantitative FA value could help better reveal different changes of microstructural integrity between different opportunistic infections.

Keywords: AIDS; Tuberculosis; Toxoplasmosis; Diffusion tensor imaging; FA value; ADC value

1. Introduction

Diffusion tensor imaging (DTI) is a quantitative imaging method which was developed on the basis of diffusion weighted imaging (DWI). Main indexes include apparent diffusion coefficient (ADC) and fractional anisotropy (FA) AIDS combined with opportunistic infections can lead to severe central nervous symptoms with high mortality. To non-invasively display the pathophysiological changes of infected brain tissues, DTI technology was applied to obtain FA and ADC values and three-dimensional cerebral white matter beam employed to trace them. All of these provide effective basis for the research of AIDS associated opportunistic infections as well as for the clinical treatments.

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2. Methods

2.1. Subjects

Data of 22 patients with AIDS who were hospitalized during August 2013−August 2014 in Xinjiang Uyghur Autonomous Region Infectious Disease Hospital were collected. There were 17 male and 5 female patients, aged from 21 to 56 years old with a mean of 34 years old. Merely 13 patients have been taking drugs for 6 months to 5 years with an average of 3 years for antiviral treatment. Recent CD4+ cell counts revealed that had $CD4^{+}$T cell count was below 200 cells/mm^3 in 15 cases, and above 200 cells/mm^3 in 7 cases. The major clinical manifestations of the patients were headache and dizziness in 15 cases, emesis in 9 cases, hemiplegia in 5 cases, aphasia in 2 cases, epileptic seizure in 1 case, such tuberculosis symptoms as low fever, night sweat, emaciation and fast erythrocyte sedimentation rate in 5 cases, blurred vision and eye quiver in 2 cases, limb ataxia in 3 cases and cerebral infarction in 2 cases. Finally, 12 patients were confirmed with brain tuberculosis (TB) by cerebrospinal fluid (CSF) laboratory examination or clinical features and 10 patients with cerebral toxoplasma (CT) for clinical symptoms or effective clinical treatment trials. All of the patients have signed the informed consent as well as the confidentiality agreement about the state of illness.

2.2. MRI examination

Routine MRI plain scan (including axial view T1Wl, T2WI and T2 flair), spin-echo DTI sequence and T1WI contrast enhancement (T1-CE) sequence (including axial view, sagittal view and coronal view) scan were conducted by the Philips Achieva 1.5 T double gradient MRI scanner and 16 channel head and neck joint coil SENSE acquisition techniques. Gadolinium diamine injection, a synergist by GE' pharmaceutical Co. Ltd was applied at a dosage of 0.1 mmol/kg. The following parameters were used to acquire data from all participants: Axial view T1WI SE: TR/TE 488 ms/15 ms, Matrix 268 × 384, NEX 1; Axial view T2WI FSE: TR/TE 4080 ms/110 ms, Matrix 232 × 256, NEX 2; Axial view T2 flair: TR/TE 6000 ms/120 ms, Matrix 252 × 512, NEX 1; DTI SE-EPI sequence: TR/TE 2644 ms/55 ms, Matrix 112 × 128, b=(0, 1000 s/mm^2), exerting diffusion sensitive gradient in 16 directions, NEX 1, Thick/gap 6 mm/1 mm. All enhanced scanning was implemented with T1WI sequence.

2.3. Data processing and analysis

Subjective indicators such as the characteristics of lesion signals in every sequence and tabulated data were reviewed by two senior radiologists independently. In case of disagreement, consensus would be reached. The FA and ADC maps were calculated automatically after the original data of DTI sequence being sent to the post-processing workstation. With reference to corresponding axial T2WI, T2 flair and T1-CE maps, region of interest (ROI) was defined, with the clearly enhanced solid area of lesion as the solid area and region of abnormal signals outside the solid area as edema area. The corresponding ROIs of the offside normal brain parenchyma were manually drawn to assess FA and ADC values. Each of the manually shaped ROIs had an arbitrary, irregular contour to match the shape of solid, necrosis and edema area.

The values of FA and ADC of the solid and peripheral edema areas of lesions and contralateral normal brain parenchyma were measured for 3 times in different infections. The means and standard deviation of the values were adopted for statistical analysis. Then the shapes of fiber bundles of the brain white matter at and adjacent to different infected lesions as well as the corresponding opposite areas were observed on the diffusion tensor tractography (DTT). Thereafter, the FA and ADC values represented by (mean ± SD) were analyzed with SPSS17.0. Statistical analysis of the two different groups was performed by independent sample *t*-test. Analysis of variance (ANONA) was used for the three regions of each group. $P < 0.05$ was considered of statistically significant difference.

3. Results

12 cases were diagnosed with tuberculosis infections. 3 cases were revealed with pure single lesion, 7 cases with 19 lesions implicating the brain gray and white matter, and 5 cases combined with brain parenchyma and meningeal infection. The tuberculosis foci in the brain parenchyma was scattered or aggregated in a diameter of 3−28 mm. The solid parts of tuberculosis granuloma presented with equal or slightly low signals on T1WI, and well-demarcated high signals on T2WI. After MRI enhanced scanning, tuberculosis foci displayed nodular and ring enhancement and also some visible typical target signs (Fig. 1A−B). Due to the small size of some nodules, there were 17 lesions evaluable of ADC and FA values. ADC maps: 6 lesions had slightly equal or high signals at the substantial part, and 11 lesions manifested high signals. The edges of most tuberculosis lesions and the peripheral edema showed low signals. FA maps: a majority of tuberculosis foci showed equal or low signals (Fig. 1C−F).

Meanwhile, 10 cases with cerebral toxoplasma manifested multiple foci with a diameter of 4−31 mm. 18 lesions of 8 cases were detected in basal ganglia and the junction of cerebral gray and white matters, which manifested quasi-circular low signals on T1WI and slightly high signals on T2WI. The solid parts of the foci and the surrounding edema were ill defined, and the signals of solid areas were lower than those of the edema areas. Small lesions manifested even signals, uneven nodular and ring enhancement by enhanced scan. However, larger lesions manifested central necrosis with obvious mass effect (Fig. 2A−B). In this group, ADC and FA values of 16 lesions were measured. ADC maps: the solid parts had even or uneven high signals and the surrounding edema areas had equal signals. FA maps: the substantial part of the foci had iso-hypointensity signal (Fig. 2C−F).

One-way analysis of variance test unveiled that the ADC and FA values of the solid areas, edema areas and normal areas of the two groups showed statistically significant difference