Perilesional area of Brain Tumors: A longitudinal diffusion tensor imaging study

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Introduction

Peritumoral signal abnormalities (PSA) of brain tumors contain varieties of tissues, and are categorized mainly to abnormal protons (vasogenic edema, gliosis) and/or tumor infiltration. In clinical experience, T2-weighted MR images are usually used to identify PSA in patients with tumors, even though the two types of signal abnormalities can still hardly be distinguished effectively up to date. Several studies have aimed to reflect peritumoral microstructures using Diffusion Tensor Imaging (DTI) stemming from the consideration that abnormalities may have different diffusion properties on DTI. However, conflict results have been obtained plausibly due to the assumption that T2-signal changes surrounding meningiomas which consist of vasogenic edema and those surrounding gliomas which consist of tumor infiltration [1-4]. In an attempt to circumvent this problem, a novel method was proposed and DTI was applied to differentiate the complex contents of PSA by reversibility. Differentiating tissue contents of PSA may facilitate tumoral delineation and therefore change the therapeutic strategy.

Methods

Twenty-nine patients (Mean age: 53.1 y/o, range: 9-78 y/o; 16 men and 13 women), twenty-seven patients with surgical and pathological proved brain tumors, two patients with imaging diagnosis, were recruited for the study. Seventeen of them (five meningiomas, five anaplastic astrocytomas-AA, and seven glioblastomas-GBM), who presented PSA and had longitudinal follow-up MR imaging were recruited in the current analysis. MR scanning was performed before surgery and two to three months after tumor resection. All MR scans were performed on a 1.5T MR system (Excite II; GE Medical Systems, Milwaukee, Wis., USA) with an eight channels head coil at the Veterans General Hospital Taipei. Pre-surgical MR imaging included: whole brain conventional T1-weighted imaging (T1W) with TR/TE=550/15 ms, voxel size=1 x 1 x 5 mm^3 was performed on the axial plane before and after Gd-DTPA administration; T2-weighted imaging (T2W) with TR/TE=3000/90 ms and same resolution was performed by using FSE sequence. Finally single-shot spin-echo EPI DTI sequence with TR/TE = 17000/68.9 ms, voxel size = 2 x 2 x 2.2 mm^3, b = 1000 s/mm², 13 directions, and NEX = 6 was performed. PSA were defined as abnormal high signals on T2W around the Gd-enhanced tumor mass and classified as reversible if they were normalized in the follow-up MR imaging and as irreversible if abnormal high signals remained. For each patient, the region-of-interest (ROI) was placed in both PSA and its mirror area of the contralateral hemisphere on T2W and fractional anisotropy (FA) map. Lesion-to-Non_Lesion FA ratios of ROIs were determined accordingly. All raw data were transferred to a computer workstation for analysis using an in-house developed program. Non-parametric Mann-Whitney U test was conducted in commercial statistical software package (SPSS 12.0; SPSS, Chicago, Ill). P values less than 0.05 were deemed to indicate a statistically significant difference.

Results

Reversible PSA were found in eight patients (three meningiomas, two AA, and three GBM) and irreversible in twelve patients (three meningiomas, three AA, and six GBM). FA ratios for reversible group and irreversible group were 0.511±0.089 and 0.306±0.056, respectively with statistically significant differences (p<0.0001). Under reversible edema group, FA ratios for meningiomas (n=3) and gliomas (n=5) were 0.479±0.073 versus 0.530±0.101, respectively; under irreversible edema group, FA ratios for meningiomas (n=4) and gliomas (n=9) were 0.292±0.061 versus 0.321±0.057, respectively. Intra-group FA ratios were not significant differences among tumor types (p=0.393 and 0.604). High-grade gliomas with irreversible PSA showed a strong probability (64%). The probability of meningiomas with reversible PSA was 43% and that with irreversible PSA was 57%.
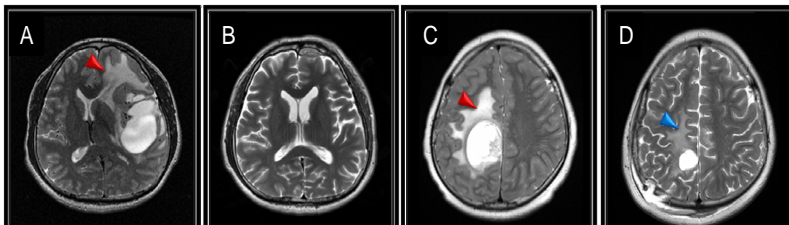

Fig. 1 Reversibility. T2W images in a patient with meningioma (A-B). A: Pre-surgical T2W image showed abnormal high signals in the left hemisphere (red arrow). B: Post-surgical T2W image showed abnormal high signals had been normalized to normal level. In this case, the patient is therefore regarded as reversible PSA category. T2W images in a patient with AA (C-D). C: Pre-surgical T2W image showed abnormal high signals in the right hemisphere (red arrow). D: Post-surgical T2W image showed abnormal high signals still remained (blue arrow). In this case, the patient belonged to irreversible PSA category.
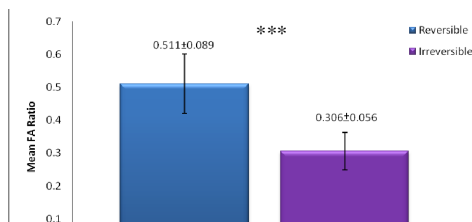

Fig. 2 Mean FA ratios for reversible group and irreversible group were 0.511±0.089 and 0.306±0.056, respectively, with a statistically significant difference (p<0.0001).

Conclusions

The reversibility of PSA was predictable by FA ratios on DTI. Of the seventeen patients with longitudinal data, the results showed that the FA ratio of peri-tumoral/contro-lateral normal white matter were 0.511 and 0.306, respectively, for reversible and irreversible signal abnormalities, with statistically significant difference. Furthermore, the irreversibility is irrelevant to tumor types. These findings support our hypothesis that the two types of PSA contain different components and can be applied to predict the post-surgerical reversibility of peritumoral edema. The new model for characterization of peritumoral tissues can assist to categorize peritumoral edema by tumor type in the previous studies and allows us to refine the delineation of therapeutic targets. It may not only predict post-surgical outcome but also serve as a biomarker for targeting delineation and therefore improving therapeutic effects.

References

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