

Imaging

Assessment of therapeutic response in patients with brain abscess using diffusion tensor imaging

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Abstract

Background: Accurate assessment of therapeutic response in patients with brain abscess (BA) is essential to direct appropriate therapy. This study was performed with an aim to see the treatment-induced changes in diffusion tensor imaging (DTI) indices (ie, fractional anisotropy [FA] and mean diffusivity [MD]) in follow-up patients with BA after treatment.

Methods: Twenty patients with BA were prospectively studied in this study. Diffusion tensor imaging in first follow-up was done in all after 1 week and in 6 at 4 weeks of the initial study.

Results: The mean FA and MD values in first, second, and third studies were 0.28 ± 0.03 and $(0.81 \pm 0.07) \times 10^{-3}$ mm²/s, 0.18 ± 0.09 and $(1.08 \pm 0.09) \times 10^{-3}$ mm²/s, and 0.13 ± 0.04 and $(0.99 \pm 0.13) \times 10^{-3}$ mm²/s, respectively. The FA value was significantly ($P < .01$) decreased along with no significant change in MD value ($P = .08$) for 3 study periods. The mean volume (in milliliter) of the abscesses was 2.14 ± 1.04 , 1.34 ± 0.45 , and 0.77 ± 0.14 in first, second, and third studies, respectively.

Conclusions: We conclude that the reduction in FA value reflects the down-regulation of the neuroinflammatory molecules in response to treatment in patient with BA and may be used to assess therapeutic response in these patients in future.

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Keywords:

Brain abscess; Diffusion tensor imaging; Fractional anisotropy; Mean diffusivity; Proton magnetic resonance spectroscopy

1. Introduction

Brain abscess development involves the inflammatory responses of the brain to restrain causative microorganisms

Abbreviations: ADC, Apparent diffusion coefficient; ANOVA, analysis of variance; CAM, cell adhesion molecule; CNS, central nervous system; DTI, diffusion tensor imaging; DWI, diffusion-weighted imaging; ETL, echo train length; FA, fractional anisotropy; FOV, field of view; FSE, fast spin echo; Gd-DTPA-BMA, gadolinium–diethylenetriamine pentaacetic acid–bismethylamide; ICAM-1, intercellular adhesion molecule-1; MD, mean diffusivity; MRI, magnetic resonance imaging; NEX, number of excitations; NIH, National Institutes of Health; PMRS, proton magnetic resonance spectroscopy; ROI, region of interest; SE, spin echo; SNR, signal-to-noise ratio; TE, echo time; TR, repetition time

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from spreading by eliciting local inflammatory cell infiltration and edema and, later, by the formation of a distinct collagenous capsule. The stereotactic aspiration has recently become the most commonly used technique to treat brain abscess. Despite the advent of modern neurosurgical techniques and new powerful imaging technologies, intracranial pyogenic bacterial suppuration remains a potentially fatal central nervous system (CNS) infection [15,17].

In vivo proton magnetic resonance spectroscopy (PMRS) and diffusion-weighted imaging (DWI) have been used to assess the therapeutic response in patient with brain abscess [16]. It has been reported that responses to treatment in patient with brain abscess could be monitored by showing the changes in metabolite patterns in serial spectroscopic studies [5]. However, the small size of the lesion restricts the accurate placement of voxel in follow-up patients and hence

may affect the actual metabolite information [17]. Restricted diffusion with low apparent diffusion coefficient (ADC) on DWI is characteristic of an abscess, whereas reverse is true for cystic tumors [4]. However, it has been shown that there may not be restriction of diffusion in the brain abscess, and this may cause problem in separating abscess from cystic neoplasm [19]. It is known that treated brain abscesses (medically and/or surgically) have higher ADCs compared to untreated abscesses. It is further reported that return to low ADCs in an abscess after treatment is suggestive of reactivation of the disease [3]. The role of DWI in monitoring the response to the surgical treatment in patients with intraventricular rupture of a cerebral abscess has been also reported [6]. However, measurement of ADC does not provide the correct information of disease activity as it primarily reflect the restriction to water diffusion even also in absence of viable cells.

Diffusion tensor imaging (DTI) is a novel magnetic resonance (MR) technique and has been used in the evaluation of various physiologic and pathologic processes. The 2 commonly used DTI-derived metrics are the fractional anisotropy (FA) and the mean diffusivity (MD). These 2 DTI-derived metrics are not related to each other [9]. This technique has been primarily applied in understanding the white matter pathologic conditions that are not detectable with the conventional MRI [12]. Recently, it has shown applications in nonwhite matter conditions such as cortical

maturation, brain abscess, hemorrhagic lesions, and epidermoids [8,10,11,13]. High FA in the brain abscess cavity has been recently shown and is attributed to be due to the adherent inflammatory cells giving the appearance of the oriented structures [8]. In case of sterile brain abscess, the high FA value was also observed that correlated with the neuroinflammatory markers, and it was further suggested that the FA can be used as a marker of disease activity even in the absence of the bacterial load [8].

In the current study, we performed the serial DTI study in follow-up patients with brain abscess after surgical aspiration on medical treatment. We hypothesized that the reduced FA value in the brain abscess cavity of follow-up patients should reflect the down-regulation of inflammatory cytokines and in turn response to treatment.

2. Material and methods

2.1. Subjects

Twenty patients with brain abscesses were prospectively studied in this study. The 14 males and 6 females had a mean age of 20.21 years (range, 6-39 years). Clinical signs, symptoms, and causative organism are summarized in Table 1. In all the patients, stereotactic surgical drainage of the abscess cavities was performed, followed by intravenous antibiotics. Patients with initial diagnosis of brain abscess,

Table 1
Clinical signs and symptoms

Patient/ age (y)	Neurologic signs and symptoms	Abscess	
		Location	Organism
1/8	Headache, nausea, irritability, vomiting, difficulty in walking	Left cerebellum	Streptococcus species
2/21	Headache, difficulty in speech, nausea, right hemiparesis	Left temporal	Pseudomonas aeruginosa
3/18	Right ear discharge, headache, vomiting, difficulty in walking, altered sensorium	Right cerebellum	Escherichia coli
4/35	Nausea, vomiting, disturbed mentation, lethargy, fever	Left cerebellum	Staphylococcus aureus
5/16	Headache, vomiting, dementia, personality changes	Right frontoparietal	Pseudomonas aeruginosa
6/35	Right ear discharge, headache, difficulty in walking, vomiting, altered consciousness level, fever	Right cerebellum	Streptococcus species
7/35	Headache, dysphasia, vomiting, disturbed mentation	Left temporal	Pseudomonas aeruginosa
8/10	Headache, nausea, vomiting, seizures, hemiparesis, nausea, vomiting, headache, forgetfulness, urinary incontinence, seizures, fever	Left temporoparietal	Mixed (Eikenella cordense and Bacteroides species)
9/15		Right parietal	Sterile
10/6	Headache, vomiting, gait disturbances, fever, aphasia	Right temporoparietal	Mixed (Bacteroides and Streptococcus species)
11/28	Headache, nausea, vomiting, fever, urinary incontinence, seizure	Left parietal	Gram-negative bacilli
12/28	Fever, right hemiparesis, headache, vomiting, diabetic	Right cerebellum	Sterile
13/39	Headache, vomiting, lethargy, malaise, fever, gait disturbances	Left frontal	Mixed (anaerobic cocci and Streptococcus species)
14/10	Headache, vomiting, altered sensorium, right ear discharge, difficulty in walking	Right cerebellum	Staphylococcus aureus
15/6	Posttraumatic brain abscess, headache, fever, discharge from operative wound, vomiting	Left frontal	Staphylococcus aureus
16/6	Headache, vomiting, forgetfulness, irritability, seizures	Right frontal	Anaerobic cocci
17/21	Headache, vomiting, fever	Left frontoparietal	Sterile
18/22	Fever, headache, vomiting, altered mentation, difficulty in walking	Right cerebellum	Staphylococcus aureus
19/25	Vomiting, headache, fever, altered sensorium	Right frontal	Staphylococcus aureus
20/28	Nausea, vomiting, headache	Right frontal	Sterile

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