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Original research article

The evaluation of the effects of steroid treatment on the tumor and peritumoral edema by DWI and MR spectroscopy in brain tumors

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ABSTRACT

Objective: To investigate the effects of dexamethasone on brain tumor and peritumoral edema by different sequences of magnetic resonance imaging (MRI).
Materials and methods: MRI was performed in 28 patients with brain tumor. Patients were divided into the 3 groups based on the histological diagnosis; Group I: high-grade glial tumor, Group II: low-grade glial tumor, and Group III: brain metastasis. The measurements of peritumoral edema volume and apparent diffusion coefficient (ADC) values were performed while the peak areas of cerebral metabolites were measured by spectroscopy in groups I and II. The changes in edema volumes, ADC values and cholin/creatine peak areas were compared.
Results: The volume of peritumoral edema was decreased in groups I and II, but increased in group III after dexamethasone treatment. These changes were not statistically significant for 3 groups. ADC value was decreased in group I and increased in groups II and III. Changes in ADC values were statistically significant. Cholin/creatine peak areas were decreased after dexamethasone in groups I and II, but these changes were also not significant.
Conclusion: Dexamethasone has no significant effect on the volume of peritumoral edema in glial tumor and metastasis. Moreover, dexamethasone increases the fluid movements in low grade gliomas and metastases, decreases in high grade gliomas. However, more comprehensive clinical studies are needed to show the effects of dexamethasone on brain tumors and peritumoral edema.

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1. Introduction

About 80% of brain tumors are primary, metastatic tumors contribute to the remaining 20%. Brain is the second most common site for metastasis and accounted for 15% of all metastases. Brain tumors may occur at any age, but they are observed more common between the ages of 55 and 65 years. Most common primary brain tumors are gliomas [1–4].

Glial tumors are the widest group of all intracranial tumors (40–45%) [5]. Gliomas may be solitary or multicentric [2]. These tumors are divided into 2 groups such as low-grade glioma and high-grade glioma based on histological examination of the tumor specimen. Subependymal giant cell astrocytoma, pilocytic astrocytoma, ganglioglioma, and diffuse astrocytoma are examples of low-grade glial tumors. Anaplastic astrocytoma, anaplastic oligodendroglioma and glioblastoma are the examples of high-grade glial tumors. Although the accurate diagnosis of gliomas is made by histological examination of the tumor tissue, many studies attempted to reveal some biomarkers of brain gliomas in blood and in other body fluids [3].

Metastatic tumors of the brain generate about 50% of all supratentorial brain tumors. Breast, lung, malignant melanoma, and gastrointestinal tract malignancies frequently metastasize to the brain [1,5,6].

Brain tumors are usually diagnosed with imaging techniques. Currently, magnetic resonance imaging (MRI) is widely accepted all over the world as the best imaging study for the detection of brain tumors [5]. The characteristics of solitary metastasis and primary gliomas are non-specific in conventional MRI studies and cannot be reliably distinguished by this examination. Contrast agent uptake of tumor cells can be seen both of tumors and varying degrees of peritumoral edema can be observed in MRI of patients. The most important criteria for histological grading of gliomas are vascular proliferation and the degree of cellularity. Contrast-enhanced MRI scans may provide information about the vascularity of tumor. Diffusion-weighted and diffusion-tensor imaging may be useful to provide information about cell density of tumor. Metastases and high grade gliomas cause different types of peritumoral edema in the brain. Infiltrative edema is observed in gliomas, while metastases form pure vasogenic edema. Apparent diffusion coefficient (ADC) measurements are used to separate these two types of edema in the brain [6]. Magnetic resonance spectroscopy (MRS) is a method that distinguishes tissue metabolites using different resonance peaks [7]. High cellularity and cell-cycle secondary choline (Cho) increase are usually seen in gliomas and N-acetyl aspartate (NAA) reduction draw attention when neurons were replaced by mass or normal neurons take damage. Cho signals are higher in high grade gliomas compared to low grade gliomas.

Dexamethasone is a main glucocorticoid agent that is used to treat brain edema secondary to tumors. It was begun to use in the early 1960s and it was previously shown that the preoperative dexamethasone administration reduces peritumoral edema and so mortality. Daily dose may range about 4–100 mg/day. It is also reported that the most powerful effect of steroids begins within 24–72 h of treatment [8,9]. Dexamethasone treatment decreases brain edema without distinct absorption effect. Although there are a lot of articles about dexamethasone's effect on reduction of tumor size in addition to decreasing brain edema, these statements are not widely accepted by scientists [8,10].

The purpose of this study is to investigate the effects of dexamethasone on the intensity of primary tumor and peritumoral edema using advanced MRI techniques. Diffusion-weighted imaging (DWI), T2-weighted-MRI and MRS were used for this purpose.

2. Materials and methods

After receiving approval from our national ethics committee (Approval no: 25.04.2012/i B.10.4.ISM.4.06.68.49), 28 patients were enrolled in this study. All of the patients were over the 18-years old and signed written consent form for this study. Pregnant women and patients who previously underwent brain tumor surgery had been excluded from this study. Seventeen of 28 patients were male and 11 were female. Mean age was 46 years (46.00 ± 18.33) for male patients and 54.45 (54.45 ± 13.32) years for female patients. Based on histological diagnosis, the patients were divided into 3 groups:

- **Group 1**: High-grade tumors ($n = 11$)
- **Group 2**: Low-grade tumors ($n = 10$)
- **Group 3**: Metastatic tumors ($n = 7$)

The diagnosis was high grade glial tumor in 11 patients, low grade glial tumors in 10 patients and metastasis in 7 of 28 patients. One of the high grade tumors was gliosarcoma, while the others were glioblastoma. One of the low grade glial tumors was ganglioglioma, 2 were pleomorphic xantoastrocytomas, 2 were oligodendrogliomas and 5 were diffuse astrocytomas. One of the metastatic tumors was breast cancer metastasis, the others were lung cancer metastasis. Locations of tumors were frontal, temporal, parietal and occipital lobes respectively in order of frequency.

The main complaints of patients were headache, fatigue, arm or leg weakness, seizure and speech disorder. Complaints were much more in the patients with metastatic tumors and high grade gliomas. Eleven of 28 patients had normal neurological examination; neurological deficit was present in remaining 17 patients at different levels. Patients with neurological deficits were 94.5% of metastasis and high grade glioma patients.

All patients with the diagnosis of brain tumor were screened using 3T magnet (Achieva 3 T, Philips Medical Systems, The Netherlands) preoperatively. Besides with axial T1- and T2-weighted spin-echo imagings, T2-A fluid attenuated inversion recovery (FLAIR), diffusion-weighted axial echo-planar, and post-contrast axial, coronal and sagittal images were also obtained. Spectroscopy sequences were also performed. Magnetic resonance sequences which were used in this study are shown in Table 1. Eight-channel head coil was used during the cranial MRI. Ten milliliters of intravenous gadoterate meglumine (Dotarem®, Guerbet) was administered in contrast-enhanced studies. MRI's were performed pre-treatment and 48 h after the initiation of steroid treatment. A total of 32 mg (16 mg/day × 2) dexamethasone was used as a

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