MR findings in Acute Disseminated Encephalomyelitis in Children

Wha-Young Kim, M.D., In-One Kim, M.D., Woo Sun Kim, M.D., Kyung Mo Yeon, M.D.

Purpose: We reviewed the distribution of lesion and the characteristics of the MR findings of acute disseminated encephalomyelitis (ADEM) in children. We evaluated the differences in the imaging findings and the clinical outcomes between the patients with deep gray matter involvement and the patients without deep gray matter involvement.

Materials and Methods: We retrospectively reviewed the 62 MR examinations of 21 patients who were discharged with the clinical diagnosis of ADEM. The patients were aged from 13 months to 12 years old (mean age: 4.5 years). Follow-up MR examinations were done one to 5 times (mean: 3 times) for 2 weeks to 4 years (mean: 3 months) after the initial examination. We compared the signal intensity on T2WI, the enhancement and residue on the MR images and the clinical outcomes between the patients with deep gray matter involvement and the patients without deep gray matter involvement.

Results: A total of 21 patients had white matter abnormalities on their initial MR. Fifteen patients (71%) had foci of increased signal intensity on T2WI in the deep gray matter: thalamus \( n = 15 \), globus pallidus \( n = 14 \) and putamen \( n = 10 \). On the follow-up images, all patients showed decreased signal intensity and enhancement of their lesion. We could not find the significant differences in signal intensity, enhancement and residue on the MRIs and also the clinical outcomes between the patients with deep gray matter involvement and the patients without deep gray matter involvement \(< .05\).

Conclusion: There were no significant differences in the characteristics of the imaging and the clinical outcomes between the ADEM patients with deep gray matter involvement and those ADEM patients without deep gray matter involvement.

Index words: Encephalitis
Brain, MR
Spine, MR
Acute disseminated encephalomyelitis (ADEM) is also called postinfectious or postvaccinal encephalomyelitis, and it is an uncommon inflammatory demyelinating disease of the central nervous system. The syndrome was first described in 1724 by Clifton after administering a smallpox vaccine [1]. This illness can be readily diagnosed by the clinical symptoms and MR imaging. Although it is classically considered as a white matter disease, deep gray matter involvement is not uncommon and has been reported on in both the pathological and radiologic literature [2-4].

We evaluated the distribution of the lesions and the MR imaging finding of ADEM in children, and we compared the results of the imaging and the clinical outcomes between the patients with deep gray matter involvement and those patients without deep gray matter involvement.

**Materials and Methods**

We retrospectively reviewed 62 MR examinations of 21 patients who were discharged with the clinical diagnosis of ADEM from 1994 to 2002. The patients were aged from 13 months to 12 years old (mean age: 4.5 years). 17 of these 21 patients presented with acute neurological deficits about 1 to 3 weeks after a viral illness, there was no specific history in 3 patients and 1 patient had just undergone vaccination. The symptoms included altered mentality in 11 patients, seizures in 7 patients, voiding difficulty in 5 patients, fever in 3 patients and other neurologic deficits such as cranial nerve palsies, tremor, increased deep tendon reflex, ataxia and hemiparesis. CSF revealed mild pleocytosis in 10 patients. The cultures were negative for bacteria, fungi and virus for all patients. Brain MR was initially performed for all patients before starting steroid therapy. The MR examinations were performed on several 1.5 T units. The T1-weighted images (TR/TE; 500-550/14-21) were obtained in the axial, sagittal and coronal planes. The T2-weighted images (TR/TE; 3500-4000/40-90) were obtained in the axial and coronal planes. T1-weighted axial images were performed after intravenous gadopentetate dimeglumine injection (0.1 mmol/kg). One patient showed an increased deep tendon reflex and symptoms of myelopathy, and so whole spinal MR was additionally performed. Follow-up MR examinations were performed in all patients 1-5 times for each patient (mean: 3 times) during a period of 2 weeks to 4 years (mean: 3 months) after the initial examination and treatment with steroid.

The locations of the abnormal signals in the cerebral and cerebellar white matter, deep gray matter, brainstem and spine were evaluated at the initial MR examinations. We divided the patients into two groups: group I patients revealed the lesions in the deep gray matter and white matter, and group II patients revealed the lesions only in the white matter.

The signal abnormalities of the lesions on T2WI were compared with that of the CSF and this was graded as higher intensity, iso-signal intensity or lower signal intensity than that of the CSF. The enhanced lesions on post contrast examination were correlated with the grade of the signal intensity on T2WI. We also compared the residue on the follow-up MR examinations and the clinical outcome such as neurological sequela according to the grade of the signal intensity on the T2WI and the enhancement.

We compared the signal intensities on T2WI, the enhancement, the residue and the duration from onset to recovery (the hospitalization period) between Groups I and II. We used the Mann-Whitney test and p-values <0.05 were considered significant.

**Results**

All the patients (n=21) had white matter abnormalities at the initial MR examinations (Fig. 1-3). The locations of the abnormal signal intensity in the white matter and deep gray matter are summarized in Table 1. The white matter was symmetrically involved in 11 patients. The lesions were variable in size and shape. There was no mass effect by the lesions. The cerebellum was involved in 8 patients, the brain stem in 7 patients and the thoracic spinal cord in 1 patient.

The signal intensity of the lesions was lower than that

<p>| Table 1. Location of Abnormal Signal Intensities on the Initial MR in Patients with ADEM |
|------------------------------------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Location</th>
<th>Number of patients</th>
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<tbody>
<tr>
<td>White matter (WM)</td>
<td>21</td>
</tr>
<tr>
<td>Subcortical WM</td>
<td>14</td>
</tr>
<tr>
<td>Deep WM</td>
<td>11</td>
</tr>
<tr>
<td>Internal capsule</td>
<td>8</td>
</tr>
<tr>
<td>External capsule</td>
<td>1</td>
</tr>
<tr>
<td>Corpus callosum</td>
<td>5</td>
</tr>
<tr>
<td>Deep gray matter</td>
<td>15</td>
</tr>
<tr>
<td>Thalamus</td>
<td>15</td>
</tr>
<tr>
<td>Globus pallidus</td>
<td>14</td>
</tr>
<tr>
<td>Putamen</td>
<td>10</td>
</tr>
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</table>
of the CSF on T2WI in 14 patients (Fig. 1, 2) and there was higher or iso-signal intensity compared with that of CSF in 7 patients (Fig. 3). On the post-contrast images, 6 of 21 patients showed enhancement of some, but not all lesions. All the enhanced lesions included portions of higher or iso-signal intensity compared with the CSF on T2WI. Six (86%) of seven patients with higher or iso-signal intensity on T2WI showed enhancement of their lesions (Fig. 1, 2). Three of six patients with enhanced lesions had neurological sequelae.

On the follow-up images, the signal intensity on T2WI and the extent of enhancement of the lesions were decreased in all patients (Fig. 1-3). Three patients revealed the residue of focal high signal intensity on the follow-up T2 weighted images 3-6 months after their initial examinations (Fig. 1C). Two of the focal residues demonstrated higher or iso-signal intensities on T2WI, compared with the CSF, and one revealed lower signal intensity on T2WI.

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**Fig. 1.** A 2 year-old boy with hemiplegia and an altered mentality.
A. The subcortical white matter of both the frontal lobe and left parietal lobe, the internal and external capsules and parts of the left basal ganglia and thalamus shows increased signal intensities on T2WI at the initial MR. Some of the lesions reveal higher or iso-signal intensities compared with that of the CSF on T2WI.
B. On post-contrast image, some of the lesions in both frontal lobes and the external capsules are enhanced, but the left side is more strongly enhanced than the right side.
C. Follow-up MR after 4 months shows resolution of the white matter abnormality with focal residue in the left thalamus.

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**Fig. 2.** A 7 year-old girl with dysarthria and vomiting.
A. Ill-defined increased signal intensities are revealed in the left cerebellar hemisphere and brainstem on axial T2WI. Higher or iso-signal intensities compared with that of CSF are identified in the medial aspect of the left cerebellum.
B. On the post-contrast T1WI, a part of the left cerebellum is enhanced.
C. Follow-up MR after 6 months shows little residue in the cerebellum and brainstem, and the parenchyma was not enhanced (not shown).
intensities than the CSF. One patient with focal residue in the left basal ganglia had a seizure. Five patients revealed mild brain atrophy on the final MR images 2-4 years after the initial examinations. Three of them had a neurological sequela of persistent seizure, motor deficit or intellectual disturbance. Two patients of five patients had involvement of the deep gray matter. Three of five patients showed lower signal intensity than the CSF on T2WI at the initial MR imaging and two of them showed higher or iso-signal intensity with CSF. Table 2 summarized the signal intensity and residue on the follow-up images and the clinical outcomes between groups I and II. We could not find any statistically significant differences between the two groups ($p=0.850$).

We also performed whole spine MR in the patient who showed an increased deep tendon reflex and voiding difficulties; this demonstrated a slightly thinned spinal cord and relatively long linear segments of high SI at the level of the thoracic spine on the T2 sagittal scan. The brain MR imaging was negative in this patient.

**Discussion**

ADEM usually affects children or young adults, and the patients usually present with an acute or subacute illness for up to 3 weeks after an infection or vaccination, or they are without a recognizable preceding event. In most patients the disease is monophasic, lasting from 2 to 4 weeks, with no relapse or recurrence of the neurological signs or symptoms. Relapses may occur immediately after ADEM and if these relapses are thought to represent part of the same acute monophasic immune process, then the term multiphasic disseminated encephalomyelitis is used (5).

Neuroimaging has been established as being extremely useful for diagnosing ADEM. MR is highly sensitive and it’s usually required to make the diagnosis (4-12). On the long TR images, the lesions are seen as bilaterally asymmetric or symmetric foci of high signal intensity in the diffuse white matter. The lesions vary greatly in size and number, and they usually show no evidence of hemorrhage or a mass effect. The MR findings lack specificity because of the wide radiological spectrum (4). There may be a delay between the onset of symptoms and the appearance of lesions on MR images (11).

Histologically, multifocal perivenous infiltrations with lymphocytes and plasma cells are seen with edema and demyelination (7). The same intense inflammatory re-

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**Table 2.** Comparison of the Imaging, the Residue on MR and the Clinical Outcomes Between Group I and Group II

<table>
<thead>
<tr>
<th>Results</th>
<th>Group I $n=15$</th>
<th>Group II $n=6$</th>
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</thead>
<tbody>
<tr>
<td>SI (&gt; CSF) on T2WI ($n=7$)</td>
<td>5 (33%)</td>
<td>2 (33%)</td>
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<tr>
<td>Enhancement ($n=6$)</td>
<td>5 (33%)</td>
<td>1 (17%)</td>
</tr>
<tr>
<td>Atrophy ($n=5$)</td>
<td>4 (26%)</td>
<td>1 (17%)</td>
</tr>
<tr>
<td>Focal residual lesion ($n=3$)</td>
<td>2 (13%)</td>
<td>1 (17%)</td>
</tr>
<tr>
<td>Neurological sequelae ($n=7$)</td>
<td>5 (33%)</td>
<td>2 (33%)</td>
</tr>
<tr>
<td>Improvement of neurological Sx. ($n=7$)</td>
<td>9-39 D (mean 30 D)</td>
<td>9-75 D (mean 34 D)</td>
</tr>
</tbody>
</table>

SI: signal intensity, D: day, Sx.: symptoms
sponse is also known to occur in the deep gray matter [3]. The deep gray matter also contains myelin, as well as oligodendrocytes, the main function of which is to form and maintain myelin. Deep gray matter involvement has been reported in a couple of series at a variable rate of 40-61% [2, 3]. In our series, deep gray matter involvement occurred in 71% of the patients. When comparing with the results of our series between the patients with involvement of the deep gray matter and the patients without involvement of the deep gray matter, we could not find significant differences in signal intensities, enhancement of the lesions, residue and the clinical outcomes between the two groups. Follow-up MRI has demonstrated a marked decrease in the size and number of lesions with complete resolution of some areas of demyelination with steroid therapy, which also tends to parallel the course of clinical improvement [12-14]. In our study, three of five patients with persistent brain parenchymal atrophy and one of three patients with a residue on follow-up MR examinations had a neurological sequela. Reversible corticosteroid-induced cerebral shrinkage may be seen and this can be confused with a permanent cerebral atrophic process [15].

The enhancement seen in demyelinating processes is caused by a local breakdown of the blood-brain barrier in the early stage. Since ADEM is usually a monophasic disease, it has been postulated that all of the lesions should enhance since they should all be active. However, enhancement of the lesions in ADEM may be differ in the degree of damage to the blood-brain barrier and this might be prolonged for at least several weeks [16, 17]. In our series, the lesions with higher or iso-signal intensity on T2WI compared with CSF signal intensity were enhanced on the post-contrast images in six of seven patients. Three of them had neurological sequelae. Yet we only had a small number of subjects and further study is needed.

The most important radiological differential diagnosis is multiple sclerosis. In contrast to multiple sclerosis, ADEM presents with fever, meningeal irritation and a reduced conscious level: also unlike the findings of multiple sclerosis, new lesions do not develop with time [16]. The serial MR images make a useful contribution to the distinction between multiple sclerosis and ADEM, but some cases of recurrent ADEM have been reported [5]. We found that 71% of the cases in our study involved the deep gray matter. Some authors insisted that this finding might be useful in distinguishing ADEM from multiple sclerosis, particularly in the cases with callosal involvement [3, 18].

In summary, although ADEM commonly involves the white matter of brain, deep gray matter can also be frequently involved (71%). The lesions with higher or iso-signal intensities compared with CSF on T2WI were usually enhanced on the post-contrast images. The imaging characteristics and clinical outcomes were not significantly different between the patients with deep gray matter involvement and those without involvement.

References


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<th>Year</th>
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<td>2006</td>
<td>MR findings in Acute Disseminated Encephalomyelitis in Children</td>
<td>2006;55:395-400</td>
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