MRI Findings of Primary Intracranial Lymphoma in Immunologically Normal Patients*

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— Abstract —

Magnetic resonance (MR) images of 14 consecutive patients with pathologically proven primary intracranial lymphoma were reviewed. All patients had a brain MR imaging before any treatment and were immunologically competent. MR images were acquired using 2.0T (n=6) or 0.5T (n=8) machine. The MR images were reviewed regarding the location, multiplicity, size, signal intensity, margin, shape, and the extent of surrounding edema of the lesion. Seven patients had multiple lesions, 2 to 4 in number. A total of 26 lesions was found; 25 were parenchymal lesions and one was dural lesion. The location of tumor was either central (n=11) or peripheral (n=14). The size of tumor was variable ranging from 0.6cm to 6.0cm in its maximal diameter. The tumors were isointense (n=19) or hypointense (n=7) relative to gray matter on T1-weighted images, isointense (n=24) or hyperintense (n=2) on proton-density weighted images, and isointense (n=21) or hyperintense (n=5) on T2-weighted images. On gadolinium-enhanced T1-weighted images of 13 patients, strong enhancement was seen in 22 of 23 lesions. Nineteen lesions showed smooth, well-defined margin, whereas remaining 7 lesions showed irregular, ill-defined margin. The shape of the tumor was diverse; round of ovoid (n=15), lobulated (n=9), or short linear (n=2).

These results suggest that one should consider the diagnosis of CNS lymphoma in cases with single or multiple masses that abut CSF space and show iso- or similar intensity to gray matter with strong enhancement on MR images.

Index Words: Brain, MR 10.1214
Brain, lymphoma 10.34

Primary central nervous system (CNS) lymphoma is a relatively rare disease. It comprises about 1% of all intracranial neoplasm and about 1% of all lymphomas (1). Hodgkin disease rarely involves the brain; parenchymal lymphomas are almost exclusively non-Hodgkin lymphoma (2). Primary CNS lymphoma is one of the common complications of acquired immune deficiency syndrome (AIDS) (3). Although it is uncommon, a threefold increase in non-AIDS-related CNS lymphoma has been reported in recent years (4). This tumor is histologically similar to lymphomas originated outside of the CNS (5).

The computed tomographic (CT) findings of primary CNS lymphoma have been well docu-
mented previously. According to our knowledge, however, there have been only a few descriptions concerning the magnetic resonance (MR) imaging findings of primary intracranial lymphoma (6,7). The purpose of this article is to describe the MR features of primary intracranial lymphomas in immunologically normal patients.

MATERIALS AND METHODS

The brain MR images of 14 consecutive patients (eight men, 6 women; age range, 29-67 years) with pathologically proven intracranial lymphoma were retrospectively reviewed. All patients had brain MRI before any treatment, and they underwent chest and abdominal CT scans to exclude systemic lymphoma. The patients who had immunosuppressant therapy were excluded from this study. All pathologic specimens were reviewed and classified according to the working formulation.

MR imaging was performed with either 2.0-T (n=6) or 0.5-T (n=8) superconducting MR unit (Goldstar, Seoul, Korea), using spin-echo pulse sequences. Before contrast administration, T1-weighted (500/30, repetition time/echo time msec), proton-density-weighted (2000-3000/30) and T2-weighted (2000-3000/80-100) axial images were obtained in all patients. After intravenous injection of gadopentetate dimeglumine (0.07-0.1 mmol/Kg body weight, Magnevist®, Schering, Berlin), T1-weighted axial, coronal, and sometimes sagittal images were obtained in 13 patients. The slice thickness/gap was 5mm/2mm for the 2.0T unit and 7mm/3mm for the 0.5T unit. The matrix number was 256×256, and the spatial resolution was 1mm×1mm. The number of excitations ranged from 4 to 6 for T1-weighted images and 1 to 2 for T2-weighted images.

The MR images were reviewed regarding the location, multiplicity, size, signal intensity, margin, and shape of the mass.

The locations of the tumor were analysed as central and peripheral. The peripheral lesion was defined as the lesion located in the cortex or subcortex, and the central lesion as the le-

Table 1. Summary of Clinical Features of 14 Patients with Primary Intracranial Lymphoma

<table>
<thead>
<tr>
<th>Case No./ Age (y)/Gender</th>
<th>Presenting Symptom(s)</th>
<th>Type of Surgery</th>
<th>Histology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/33/M</td>
<td>Right hemiparesis</td>
<td>N</td>
<td>UN</td>
</tr>
<tr>
<td>2/61/F</td>
<td>Confusion</td>
<td>C</td>
<td>DL</td>
</tr>
<tr>
<td>3/35/F</td>
<td>Headaches</td>
<td>N</td>
<td>DS</td>
</tr>
<tr>
<td>4/48/M</td>
<td>Right hemiparesis</td>
<td>N</td>
<td>DL</td>
</tr>
<tr>
<td>5/57/M</td>
<td>LLE weakness</td>
<td>C</td>
<td>DS</td>
</tr>
<tr>
<td>6/55/F</td>
<td>Gait disturbance</td>
<td>N</td>
<td>DL</td>
</tr>
<tr>
<td>7/38/M</td>
<td>Disorientation</td>
<td>C</td>
<td>DL</td>
</tr>
<tr>
<td>8/67/M</td>
<td>Disorientation</td>
<td>C</td>
<td>DL</td>
</tr>
<tr>
<td>9/29/F</td>
<td>Headaches</td>
<td>N</td>
<td>DL</td>
</tr>
<tr>
<td>10/59/M</td>
<td>LLE weakness</td>
<td>C</td>
<td>DL</td>
</tr>
<tr>
<td>11/50/F</td>
<td>Decreased equilibrium</td>
<td>N</td>
<td>DS</td>
</tr>
<tr>
<td>12/50/F</td>
<td>Seizure</td>
<td>C</td>
<td>DL</td>
</tr>
<tr>
<td>13/33/M</td>
<td>Seizure</td>
<td>CSF cytology</td>
<td>DL</td>
</tr>
<tr>
<td>14/40/M</td>
<td>Headaches</td>
<td>C</td>
<td>DL</td>
</tr>
</tbody>
</table>

Note.-N, needle biopsy; C, craniotomy; UN, undetermined type; DL, diffuse large cell lymphoma; DS, diffuse small cell lymphoma; LLE, left lower extremity.
sion located in the periventricular parenchyma.

The extent of high signal intensity region around the tumor on T2-weighted image, assumed as edema, was estimated by measuring the radial distances from the margin of tumor to the boundary of high signal intensity region and normal brain on T2-weighted images.

**RESULTS**

The clinical and MR imaging findings of the 14 patients are summarized in Table 1 and 2. A total of 26 foci of abnormal signal intensity were observed in the 14 patients.

Twenty five of 26 lesions were parenchymal in location either central (n=11) or peripheral (n=14). The central lesions were found the thalamus (n=4), the basal ganglia (n=3), and the corpus callosum (n=4). Centrally located 8 lesions were abutting the ventricle. Peripherally located 14 lesions were seen in the the frontal lobes (n=7), the parietal lobes (n=4), the occipital located in the periventricular parenchyma.

### Table 2. Summary of MR Imaging Features in 14 Patients with Primary Intracranial Lymphoma

<table>
<thead>
<tr>
<th>No.of Patients</th>
<th>Lesions Location</th>
<th>Signal Intensity*</th>
<th>T1WI</th>
<th>PDWI</th>
<th>T2WI</th>
<th>Enhancement</th>
<th>Size**</th>
<th>Margin</th>
<th>Shape</th>
<th>Edema (cm)”</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Left thalamus</td>
<td>Iso Iso Iso</td>
<td>+</td>
<td></td>
<td></td>
<td>4.5</td>
<td>Smooth</td>
<td>Round</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Left parietal</td>
<td>Iso Iso Hyper</td>
<td>+</td>
<td></td>
<td></td>
<td>3.5</td>
<td>Smooth</td>
<td>Round</td>
<td>6.6</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Right Parietal</td>
<td>Hypo Iso Iso</td>
<td>+</td>
<td></td>
<td></td>
<td>4.0</td>
<td>Smooth</td>
<td>Lobulate</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Right Parietal</td>
<td>Iso Iso Iso</td>
<td>+</td>
<td></td>
<td></td>
<td>0.8</td>
<td>Smooth</td>
<td>Round</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Right frontal</td>
<td>Iso Iso Hyper</td>
<td>+</td>
<td></td>
<td></td>
<td>3.5</td>
<td>Irregular</td>
<td>Lobulate</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Left thalamus</td>
<td>Iso Iso Iso</td>
<td>+</td>
<td></td>
<td></td>
<td>4.0</td>
<td>Smooth</td>
<td>Lobulate</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Right occipital</td>
<td>Iso Iso Iso</td>
<td>n</td>
<td></td>
<td></td>
<td>3.8</td>
<td>Smooth</td>
<td>Round</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Right thalamus</td>
<td>Hypo Hyper Hyper</td>
<td>+</td>
<td></td>
<td></td>
<td>6.0</td>
<td>Smooth</td>
<td>Lobulate</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Left basal ganglia</td>
<td>Hypo Iso Iso</td>
<td>+</td>
<td></td>
<td></td>
<td>3.0</td>
<td>Smooth</td>
<td>Round</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Right frontal</td>
<td>Iso Iso Iso</td>
<td>+</td>
<td></td>
<td></td>
<td>4.2</td>
<td>Irregular</td>
<td>Lobulate</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Right basal ganglia</td>
<td>Hypo Iso Iso</td>
<td>+</td>
<td></td>
<td></td>
<td>3.0</td>
<td>Smooth</td>
<td>Round</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Left basal ganglia</td>
<td>Hypo Iso Iso</td>
<td>+</td>
<td></td>
<td></td>
<td>2.5</td>
<td>Smooth</td>
<td>Ovoid</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Left frontal</td>
<td>Iso Hyper Hyper</td>
<td>+</td>
<td></td>
<td></td>
<td>4.5</td>
<td>Smooth</td>
<td>Round</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Corpus callosum</td>
<td>Iso Iso Iso</td>
<td>+</td>
<td></td>
<td></td>
<td>3.5</td>
<td>Irregular</td>
<td>Lobulate</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corpus callosum</td>
<td>Iso Iso Iso</td>
<td>+</td>
<td></td>
<td></td>
<td>6.0</td>
<td>Irregular</td>
<td>Lobulate</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corpus callosum</td>
<td>Iso Iso Iso</td>
<td>+</td>
<td></td>
<td></td>
<td>3.0</td>
<td>Irregular</td>
<td>Round</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dura</td>
<td>Iso Iso Iso</td>
<td>+</td>
<td></td>
<td></td>
<td>4.0</td>
<td>Smooth</td>
<td>Ovoid</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: n: Enhancement was not done, +: strongly enhanced, -: not enhanced
* : signal intensity compared with normal brain gray matter
** maximal diameter of tumor in cm
” radial measurement obtained from the boundary of tumor to the edema and normal brain on T2WI.
cipital lobes (n = 3), and the temporal lobes (n = 1). One lesion was located in the dura without involvement of brain parenchyma.

Seven patients had multiple lesions, 2 to 4 in number. The size of tumor was variable from 0.6cm to 6.0cm in its maximal diameter.

The tumors were either isointense (n = 19) or hypointense (n = 7) to gray matter on T1-weighted images, isointense (n = 24) or hyperintense (n = 2) on proton-density weighted images, and isointense (n = 21) or hyperintense (n = 5) on T2-weighted images (Fig. 1, 2).

Nineteen lesions showed smooth, well-defined margin, whereas remaining 7 lesions showed irregular, ill-defined margin. The shape of the tumor was diverse; round or ovoid (n = 15), lobulated (n = 9), or short linear (n = 2) (Fig. 3, 4).

On gadolinium-enhanced T1-weighted images, strong enhancement was seen in all 13 patients (22 of 23 lesions). Twelve lesions appeared to be attached to the dura, but only 2 lesions showed dural enhancement (Fig. 5).

There was neither hemorrhagic foci nor intratumoral cysts in tumor. In one case of dural lymphoma, the tumor was ovoid, smoothly marginated, was isointense to gray matter on T1-, proton-, and T2-weighted images, and showed strong enhancement, mimicking meningioma (Fig. 6).

There was no substantial difference in MR findings between different cell types.

Surrounding edema of variable degree was seen in all parenchymal tumors, ranging from 0.5cm to 6.6cm in its radial diameter.
DISCUSSION

Primary intracranial lymphoma is a relatively rare disorder. Controversy still exists as to the origin of primary brain lymphoma. It has been described as reticulum cell sarcoma, microglioma, periepithelial sarcoma, adventitial sarcoma, plasmacytic myeloma, round cell sarcoma, or reticulo-histiocytic granulomatous encephalitis (8). Despite these confusing terms, primary intracranial lymphoma is now thought to be the counterpart of the malignant lymphoma of other sites.

In our series, most lymphomas were supratentorial in their location and abutted the ependymal or pial surface as shown in prior studies (9). Most lesions showed dense homogeneous contrast enhancement on MRI as seen in those cases reported by others (6, 7). Fifty percent of our patients had multiple lesions. In other series of primary intracranial lymphoma, the rate of multiplicity varied from 11% to 53% (1, 10).

While primary intracranial lymphoma commonly presents as ring-enhancing lesions in immunocompromised patients with human immunodeficiency virus (HIV) infection, the ring enhancement is rare in immunologically competent patients (10,11). In our study, no ring enhancement was seen in any patients. One prior study described that primary intracranial lymphomas associated with AIDS showed multiple lesions, whereas those not associated with AIDS were solitary (12). High rate of multiplicity (50%) in our study indicates multiple lesions can be associated with the lymphoma not only in immunologically normal but also in immunocompromised patients. Another study suggested that the size of primary intracranial lymphoma associated with AIDS was larger.
than that of the lesion in immunologically normal patients (6). In general, primary intracranial lymphoma was described as a smooth, well-defined round, oval mass. But in our study, irregular, ill-defined, or even linear lesion was noticed, indicating the variability of primary CNS lymphoma in its margin and shape.

The reason for the absence of enhancement in some lesions in our series is probably the lack of extracellular space resulting from tumor cell compactness or the preservation of blood-brain-barrier (13).

In our data, the extent of surrounding edema was usually moderate in degree considering the size of the mass. Some reports indicate that the surrounding edema corresponds to increased water content and infiltrating tumor cells, whereas the extent of neoplastic infiltration of the brain cannot be defined by imaging studies (7,14).

From a diagnostic viewpoint, the problem is that the MR findings of primary intracranial lymphoma overlap with those of other intracranial mass lesions. Metastases, like primary intracranial lymphomas, appear as either solitary or multiple enhancing lesions (15). High-grade astrocytomas usually exhibit marked enhancement with or without central necrosis, a periph-

Fig. 5. Case 5. Lymphoma with irregular margin and with meningeal enhancement. (Upper) Axial T1-weighted MR image (500/30) shows ill-defined lesion in the right frontal lobe which is slightly hypointense to gray matter. (Lower) After enhancement, not only the mass but the meninges (arrow) show strong enhancement on T1-weighted image.

Fig. 6. Case 14. Lymphoma arising from the dura.
a. Axial T1-weighted MR image (500/30) obtained at 0.5T shows a plaque-like mass compressing subjacent brain parenchyma (arrows) which is nearly isointense to gray matter involving the left frontoparietal dura matter.
b. Gadolinium-enhanced axial T1-weighted MR image (500/30) shows strong enhancement of the mass.
eral infiltrating margin, and a large amount of mass effect (16). Imaging findings of secondary intracranial lymphoma can be identical to those of primary intracranial lymphoma (17). Meningiomas are extraaxial-enhancing lesions that could rarely be mistaken for primary intracranial lymphoma (18). Since the imaging findings of primary intracranial lymphoma may be similar to those of the metastatic lesions, high-grade astrocytomas, secondary intracranial lymphomas, or meningiomas, it is impossible to make a confirmative diagnosis of the lymphoma in the brain. A recent study of AIDS-related primary intracranial lymphoma also showed that it was impossible to make a definite diagnosis based on imaging studies (19).

We believe that these MR findings can be used to guide the therapy of patients. Needle biopsy is the procedure of choice for obtaining a tissue diagnosis (20). In a patient whose MR scan is suggestive of primary intracranial lymphoma, a needle biopsy is a rational next step in the work-up of primary intracranial lymphoma. In the primary intracranial lymphoma, the extent of resection has no influence on the survival of patient (21). Radiation therapy, with or without adjunct chemotherapy, had been the mainstay of treatment for primary intracranial lymphoma but has yielded median survival of only about 15–20 months (22). Chemotherapy has had only modest efficacy in treating primary CNS lymphoma, but might be more effective if given before radiotherapy (23).

In summary, our study indicates that the primary lymphoma in immunologically normal patients shows following characteristics on MR images; 1. Abutting CSF space 2. Signal intensity similar to gray matter on all MR pulse sequences 3. Strong contrast enhancement 4. Single or multiple lesions 5. Variable size, margin, and shape.

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원발성 두개내 림프종의 자기공명영상소견

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원발성 두개내 림프종의 자기공명(MR)영상에서의 특징적 소견을 알아보고자, 두개내종양의 조직검사로 확진된 환자 14명에서의 두개내 림프종 26예의 MR영상상의 후향적 분석을 하였다. MR은 화학요법이나 방사선 치료전에 시행하였고, 6예에서는 2.0T, 8예에서는 0.5T MR장치를 사용하였다. 영상의 분석은 종양의 위치, 갯수, 크기, 신호강도, 경계, 모양, 부종의 정도 등을 중심으로 분석하였다. 두개내 림프종의 위치는 뇌실 주위나 기저핵부위가 11예였고, 피질이나 피질하백질 부위가 15예였다. 종양의 최대직경은 0.6-6.0cm로 다양하였고, 7명의 환자에서는 2개 내지 4개의 다발성 병소가 있었다. 두개내 림프종은 회절과 비교하여, T1 강조영상에서 동일하거나 (19예) 혹은 조금 낮은 (7예) 신호강도를 보였고, proton영상에서는 동일하거나 (24예) 혹은 조금 높은 (2예) 신호강도를, T2 강조영상에서는 동일하거나 (21예), 조금 높은 (5예) 신호강도를 보였으며, 1예를 제외하고는 모든 예에서 강한 조영증강을 보였다. 종양의 경계가 완만하고 잘 구분되는 병소가 19예였고, 경계가 불규칙하고 잘 구분되지 않는 병소가 7예였다. 종양의 모양은 다양하여, 동근 모양이 15예, 엉덩이 9예, 그리고 선형이 2예였다. 종양 주변의 부종은 그 범위가 중증도였다.

모든 MR영상에서 회절과 비교하여 동일하거나, 혹은 높은 신호강도를 보이며, 강한 조영증강을 나타내는 단발성 혹은 다발성 병소가 뇌척수액과 인접한 부위에서 관찰되며 두개 림프종의 가능성을 염두에 두어야 한다고 생각된다.