Extracerebral fluid collections in infancy: role of magnetic resonance imaging in differentiation between subdural effusion and subarachnoid space enlargement

NOBUHIKO AOKI, M.D.

Department of Neurosurgery, Tokyo Metropolitan Ohkubo Hospital, Tokyo, Japan

The pathological process of extracerebral fluid collections in infancy includes subdural effusion and enlargement of the subarachnoid spaces. Both conditions have traditionally been investigated as a single clinical entity, because of difficulty in differentiating between them. The prognosis of subdural effusion is not as benign as that of enlargement of subarachnoid spaces, requiring differential diagnosis between these disorders. The present study was conducted to elucidate whether this differentiation could be made on magnetic resonance (MR) images.

The series consisted of 16 infants aged 10 months or younger, including eight with verified subdural effusion and eight in whom a diagnosis of enlargement of the subarachnoid spaces was achieved by neuroimaging studies other than MR imaging. In all eight patients with subdural effusion, the intensity of the fluid was greater than that of cerebrospinal fluid (CSF) in at least one of the sequences using T1-weighted, proton-density, and T2-weighted MR images. The flow-void sign, indicating vessels in the fluid spaces, was not seen in any of these eight patients. On the other hand, in all eight patients with enlargement of the subarachnoid spaces, the fluid was isointense in relation to CSF, and vascular flow-void areas were seen in at least one of the MR imaging sequences. Based on these observations, it is concluded that differentiation between subdural effusion and enlargement of the subarachnoid spaces can be established by focusing on two aspects of MR imaging findings: 1) the intensity of the fluid, which is either iso- or hyperintense relative to CSF, and 2) the presence or absence of vascular flow-void areas in the fluid spaces.

Key Words: extracerebral fluid collection • subdural effusion • subarachnoid space • magnetic resonance imaging • infant

Extracerebral fluid collections in infancy include two distinct pathological conditions, one involving the subdural spaces and the other the subarachnoid spaces, manifesting as subdural effusion and enlargement of the subarachnoid spaces, respectively. Most reports on benign subdural effusion in infancy have not definitely excluded patients with enlargement of the subarachnoid spaces. Conversely, reports on enlargement of the subarachnoid spaces or external hydrocephalus seem to include patients with subdural effusion. Moreover, in some series, these two conditions were investigated as a single clinical entity with the diagnosis of extracerebral or extra-axial fluid collections in infancy. Subdural effusion in infancy is a pathological condition with chronic subdural hematoma, which may increase in volume due to exudation and repeated hemorrhage, leading to a less favorable prognosis. Furthermore, when surgical intervention is indicated, different procedures are required for these two conditions: lumboperitoneal or ventriculoperitoneal shunting is preferred for enlargement of the subarachnoid spaces, while subdural effusion is usually treated by subdural-peritoneal shunting.

For these reasons, it is necessary to differentiate between subdural effusion and enlargement of the subarachnoid spaces. Previous neuroimaging studies, including high-resolution computerized tomography (CT) scanning, cannot reliably differentiate between these conditions. In view of this, the advent of magnetic resonance (MR) imaging seems promising for definitively differentiating between subdural effusion and enlargement of the subarachnoid spaces; however, few studies have focused on the differentiation of these conditions by MR images. The aim of the present study is to elucidate whether MR images, as a single neuroimaging method, can differentiate between sub-
Extracerebral fluid collections in infancy
dural effusion and enlargement of the subarachnoid spaces.

**Clinical Material and Methods**

Between January, 1991, and December, 1992, 16 infants under the age of 12 months were referred to the Department of Neurosurgery, Tokyo Metropolitan Fuchu Hospital, for evaluation of extracerebral fluid collections by MR imaging. At the time of presentation, each of these infants was noted to have an occipitofrontal head circumference above the 98th percentile for their age, as well as an extracerebral collection more than 5 mm thick with a density indistinguishable from that of cerebrospinal fluid (CSF) on CT scanning. Based on the results of several neuroimaging studies, including CT with intravenous contrast infusion, CT cisternography, and ultrasonography, and details of the clinical history (particularly attention being paid to a history suggestive of infantile acute subdural hematoma), a differential diagnosis between subdural effusion and enlargement of the subarachnoid spaces was established in all 16 patients. Infants with extracerebral fluid collections that were not defined as being located in the subdural or subarachnoid spaces by the above-described neuroimaging methods were excluded from this study.

Eight patients were diagnosed as having subdural effusion; the diagnostic methods used included contrast-enhanced CT in five, ultrasonography in five, and CT cisternography in two. Besides these neuroimaging studies, an episode indicating infantile acute subdural hematoma was highly suggestive of subdural effusion in two patients. Subdural effusion was later verified by CT suburography and surgery in all eight patients; two also had enlargement of the subarachnoid spaces. These eight patients included four boys and four girls, ranging in age from 2 to 10 months (mean 4.6 months).

The remaining eight patients were diagnosed as having enlargement of the subarachnoid spaces; the diagnostic neuroimaging methods differentiating their condition from subdural effusion included contrast-enhanced CT in six and ultrasonography in five. These eight patients comprised five boys and three girls, ranging in age from 3 to 9 months (mean 6.25 months).

Extracerebral fluid collections in these 16 patients were evaluated by T1-weighted, proton-density, and T2-weighted MR images. Particular attention was given to the intensity of the fluid compared to that of CSF, and to the presence or absence of vascular flow-void areas in the fluid spaces.

**Results**

The intensity of the subdural effusion was greater than that of CSF in six (75%) of eight patients on T1-weighted MR images, in all six patients so studied on proton-density images, and in seven (87.5%) of eight patients on T2-weighted images (Table 1). Consequently, in all eight patients, at least one sequence of the MR images demonstrated an intensity greater than that of CSF (Fig. 1). The flow-void sign, indicating vessels in the fluid spaces apart from those in the sulci or those abutting to the cortical surface, was not delineated in any of the eight patients with subdural effusion.

In all eight patients with enlargement of the subarachnoid spaces, the intensity of the fluid spaces was consistent with that of CSF. The presence of vascular flow-void areas apart from the cortical surface was confirmed in two (25%) of eight patients on T1-weighted images, in all seven patients so studied on proton density, and in seven (87.5%) of the eight patients on T2-weighted MR images (Table 2). Consequently, in all eight patients, at least one sequence of the MR images demonstrated the flow-void sign (Fig. 2). The results of MR imaging study are listed in Tables 1 and 2.

**Table 1**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (mos), Sex</th>
<th>T1-weighted Image</th>
<th>Proton-Density Image</th>
<th>T2-weighted Image</th>
<th>Etiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3, F</td>
<td>hyper, V(+)</td>
<td>hyper, V(+)</td>
<td>iso, V(+)</td>
<td>head trauma</td>
</tr>
<tr>
<td>2</td>
<td>4, M</td>
<td>iso, V(+)</td>
<td>ND</td>
<td>hyper, V(+)</td>
<td>meningitis</td>
</tr>
<tr>
<td>3</td>
<td>6, F</td>
<td>iso, V(+)</td>
<td>ND</td>
<td>hyper, V(+)</td>
<td>acute subdural hematoma</td>
</tr>
<tr>
<td>4</td>
<td>10, F</td>
<td>hyper, V(+)</td>
<td>hyper, V(+)</td>
<td>hyper, V(+)</td>
<td>acute subdural hematoma</td>
</tr>
<tr>
<td>5</td>
<td>2, F</td>
<td>hyper, V(+)</td>
<td>hyper, V(+)</td>
<td>hyper, V(+)</td>
<td>head trauma</td>
</tr>
<tr>
<td>6</td>
<td>3, M</td>
<td>hyper, V(+)</td>
<td>hyper, V(+)</td>
<td>hyper, V(+)</td>
<td>unknown</td>
</tr>
<tr>
<td>7</td>
<td>3, M</td>
<td>hyper, V(+)</td>
<td>hyper, V(+)</td>
<td>hyper, V(+)</td>
<td>child abuse</td>
</tr>
<tr>
<td>8</td>
<td>6, M</td>
<td>hyper, V(+)</td>
<td>hyper, V(+)</td>
<td>hyper, V(+)</td>
<td>meningitis</td>
</tr>
</tbody>
</table>

* Imaging appearance relative to cerebrospinal fluid: hyper = hyperintense, iso = isointense. V(-) = absence of vascular flow-void area; ND = study not done.

**Fig. 1.** Left: Computerized tomography scan showing extracerebral fluid collections indistinguishable from cerebrospinal fluid (CSF). Right: Magnetic resonance T1-weighted image demonstrating bilateral subdural effusions, which are clearly separated from CSF in the subarachnoid spaces. Note the coexisting enlargement of the subarachnoid spaces on the right cerebral convexity (asterisk).
TABLE 2
Magnetic resonance (MR) imaging features in eight patients with enlargement of the subarachnoid spaces*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (mos), Sex</th>
<th>MR Imaging Findings</th>
<th>Etiology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>T₁-weighted Image</td>
<td>Proton-Density Image</td>
</tr>
<tr>
<td>9</td>
<td>6, F</td>
<td>iso, V(+)</td>
<td>iso, V(+)</td>
</tr>
<tr>
<td>10</td>
<td>8, M</td>
<td>iso, V(-)</td>
<td>iso, V(+)</td>
</tr>
<tr>
<td>11</td>
<td>9, F</td>
<td>iso, V(+)</td>
<td>ND</td>
</tr>
<tr>
<td>12</td>
<td>4, M</td>
<td>iso, V(-)</td>
<td>iso, V(+)</td>
</tr>
<tr>
<td>13</td>
<td>6, M</td>
<td>iso, V(-)</td>
<td>iso, V(+)</td>
</tr>
<tr>
<td>14</td>
<td>6, M</td>
<td>iso, V(-)</td>
<td>iso, V(+)</td>
</tr>
<tr>
<td>15</td>
<td>3, F</td>
<td>iso, V(-)</td>
<td>iso, V(+)</td>
</tr>
<tr>
<td>16</td>
<td>8, M</td>
<td>iso, V(+)</td>
<td>iso, V(-)</td>
</tr>
</tbody>
</table>

* Imaging appearance: iso = isointense relative to cerebrospinal fluid. V(-) = absence of vascular flow-void area; V(+) = presence of vascular flow-void area; ND = study not done.

Discussion

The diagnostic approach and treatment indications for infants with an abnormally enlarged head associated with an extracerebral fluid collection indistinguishable from CSF on CT are still uncertain. One reason for this controversy is associated with the traditional trend in which subdural effusion and enlargement of the subarachnoid spaces are managed similarly without distinguishing between them. From the author's experience, infants with subdural effusion have often had an unfavorable prognosis due to an increase in the volume of the effusion and repeated hemorrhage with subsequent development of chronic subdural hematoma. Previous reports on benign subdural effusion in infancy seem to include infants with enlargement of the subarachnoid spaces. It is necessary to evaluate the prognosis of the patient with extracerebral fluid collections after differentiating between subdural effusion and enlargement of the subarachnoid spaces.

Previous neuroimaging studies, including cerebral angiography, CT with intravenous infusion of contrast medium, CT subdurography, and ultrasonography, are known to be useful in differentiating between subdural effusion and enlargement of the subarachnoid spaces; however, cerebral angiography and CT subdurography are not practical because of their invasiveness. Moreover, in my experience, contrast-enhanced CT and ultrasonography do not always definitely differentiate between the two entities. In fact, in the present series, the diagnosis of enlargement of the subarachnoid spaces in eight patients was achieved by contrast-enhanced CT in six (75%) and by ultrasonography in five (62.5%). Magnetic resonance imaging, used as a single neuroimaging technique, is expected to offer a definitive differential diagnosis between subdural effusion and enlargement of the subarachnoid spaces. To my knowledge, however, few studies using MR imaging have focused on the differentiation of these two conditions in infancy.

In the present study, the MR imaging features were evaluated with particular attention to two aspects: 1) the intensity of the fluid compared to that of CSF, and 2) the flow-void sign, indicating vessels within the fluid spaces. It is known that subdural effusion is at times accompanied by mill enlargement of the subarachnoid spaces (Fig. 1); in this series, such patients were assigned to the subdural effusion group. In all eight patients with subdural effusion, hyperintensity relative to CSF was revealed in at least one of the MR imaging sequences using T₁-weighted, proton-density, and T₂-weighted images, and failed to delineate vascular flow-void areas. On the other hand, in all eight patients with enlargement of the subarachnoid spaces, the lesion exhibited isointensity relative to CSF, and demonstrated the presence of vascular flow-void areas apart from the cortical surface in at least one of the MR imaging sequences. These vascular flow-void areas on MR imaging are consistent with the high-density areas on CT after infusion of contrast material in patients with enlargement of the subarachnoid spaces in infancy.

It may be useful to evaluate protein content in the fluid collections and resultant signal intensity changes on T₁- and T₂-weighted images because high protein content is reportedly associated with frequent occlusion of subdural-peritoneal shunting. Moreover, although no contrast-enhanced MR images were obtained in the present series, this technique might help to demonstrate not only cortical vessels but also outer and/or inner membranes of subdural effusion, making a more definitive differentiation between the two conditions.

Theoretically, extracerebral fluid collections would include the accumulation of normal CSF in the subdural spaces and the accumulation of high-protein fluid in the subarachnoid spaces; in this series, however, no such features were delineated on MR images. This may be attributed to the small number of the patients in the present study. The differentiation between subdural effusion and enlargement of the subarachnoid spaces was established in these patients by focusing on two aspects of MR images: 1) the intensity of the fluid, which is...
Extracerebral fluid collections in infancy

iso- or hyperintense relative to CSF, and 2) the presence or absence of vascular flow-void areas in the fluid.

References

Manuscript received April 16, 1993. Accepted in final form November 3, 1993. 
Address reprint requests to: Nobuhiko Aoki, M.D., Department of Neurosurgery, Tokyo Metropolitan Ohkubo Hospital, 44-1 Kabukicho 2-chome, Shinjuku-ku, Tokyo 160, Japan.