Cerebrospinal Fluid in Cerebral Hemorrhage and Infarction

BY MYOUNG C. LEE, M.D., LOIS M. HEANEY, R.N., RONALD L. JACOBSON, PH.D., AND ARTHUR C. KLASSEN, M.D.

Abstract: Cerebrospinal Fluid in Cerebral Hemorrhage and Infarction

- Cerebrospinal fluid (CSF) abnormalities were correlated with pathological diagnoses in 61 patients with autopsy-verified intracerebral hemorrhage or cerebral infarction. Lumbar punctures were performed within one week of onset of symptoms. The CSF color and red blood cell counts were the most useful CSF parameters in differentiating between intracerebral hemorrhage and cerebral infarction. In 75% of the patients with intracerebral hemorrhage, the CSF was either grossly bloody or xanthochromic; in 25%, the CSF was clear. In patients with cerebral infarction, the CSF was never grossly bloody; in two patients with hemorrhagic infarction, the CSF was xanthochromic. The CSF pressure, protein values and leukocyte counts were less useful in differentiating intracerebral hemorrhage from cerebral infarction. Cases with hemorrhagic infarction could not be separated from those with ischemic infarction on the basis of CSF analysis. In clear CSF, the polymorphonuclear neutrophilic leukocyte (PNL) counts were never greater than 20 per cubic millimeter. In xanthochromic or cloudy CSF, leukocyte counts, especially PNLs, were frequently elevated, occasionally to high levels.

Methods

A review of the University of Minnesota Hospital records for the ten-year period between 1963 and 1972 provided 451 patients in whom postmortem examination revealed the presence of either recent intracerebral hemorrhage or cerebral infarction. This report is based on the findings in 61 of these patients in whom complete clinical and pathological information as well as the results of lumbar puncture were available. Patients with primary subarachnoid hemorrhage or head injury were excluded. Lumbar punctures were performed within one week of onset of symptoms and were considered atraumatic in all cases. All patients with intracerebral hemorrhage had gross hemorrhage into the cerebral parenchyma. Patients with cerebral infarction were divided into two groups: those without petechial hemorrhages on gross examination were designated as ischemic infarction while those with numerous petechial hemorrhages, especially in the cerebral cortex or central gray matter, were designated as hemorrhagic infarction.

In 13 of 16 patients with intracerebral hemorrhage, lumbar punctures were performed on the day of onset of symptoms (table 1). In the other three patients, lumbar punctures were performed between the second and the fourth day after onset. In 23 of 27 patients with hemorrhagic cerebral infarction, lumbar punctures were performed within three days of onset and in the other four patients, four or five days after onset. In 13 of 18 patients with ischemic infarction, lumbar punctures were performed within the first three days of onset, and, in the other five, between the fourth and the sixth day after onset.

Lumbar CSF pressure measurements were performed with patients in the lateral recumbent position. Pressures greater than 200 mm CSF were considered elevated above normal levels. In patients with grossly bloody CSF, the "three-tube test" was used to differentiate the "traumatic tap" from bloody CSF. CSF color was recorded by the physician performing the lumbar puncture; protein values and cell counts were performed in the hospital laboratory. The presence of any polymorphonuclear neutrophilic

Introduction

- In patients presenting with acute stroke syndromes it is frequently difficult to differentiate intracerebral hemorrhage from cerebral infarction. Lumbar puncture and cerebrospinal fluid (CSF) analysis are frequently used to assist in determining the etiology of the neurological deficit. Two previous studies of CSF in pathologically verified cases of stroke have presented CSF findings in considerable detail. However, these studies included patients with positive serological tests for syphilis and did not identify the time of lumbar puncture with regard to onset of stroke. Deficiencies of subsequent studies include: limitation of analysis to cytological results, inadequate numbers of autopsy-verified cases, and incomplete reporting of CSF results.

The present study was undertaken to analyze the results of lumbar puncture in autopsy-verified cases of intracerebral hemorrhage and cerebral infarction and, thereby, to determine the clinical usefulness of this procedure.

Additional Key Words

<table>
<thead>
<tr>
<th>cerebral cortex</th>
<th>lumbar puncture</th>
<th>neurological deficit</th>
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<tr>
<td>gray matter</td>
<td>intraparenchymal hemorrhage</td>
<td>autopsy</td>
</tr>
<tr>
<td>white matter</td>
<td>gray matter</td>
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</tr>
</tbody>
</table>

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leukocytes (PNLs) was considered abnormal; CSF lymphocyte counts greater than five per cubic millimeter were considered elevated. CSF protein values above 50 mg % were considered elevated.

Results
Figure 1 shows opening lumbar CSF pressures in 45 patients. In the other 16 patients, pressure values were not recorded. In patients with intracerebral hemorrhage, normal pressures were recorded in seven and elevated pressures in the other seven. In five of seven patients with elevated opening pressures, levels were greater than 300 mm CSF. Opening pressures were available in 19 of 27 patients with hemorrhagic infarction; 13 had normal opening pressures while six had pressures greater than 210 mm CSF. Pressure measurements were available in 12 of 18 patients with ischemic cerebral infarction and were normal in all but two in whom opening pressures were 210 and 230 mm CSF. Increased opening pressures thus occurred more often in patients with intracerebral hemorrhage than in those with hemorrhagic or ischemic infarction. Elevated pressures were present more frequently in patients with hemorrhagic infarction (six of 19) as compared with patients with ischemic infarction (two of 12). Pressures greater than 250 mm CSF were never recorded in patients with ischemic infarction.

As shown in table 2, the appearance of the CSF was designated as either clear, bloody, xanthochromic or cloudy. In 16 patients with intracerebral hemorrhage, the CSF was clear in four, bloody in nine and xanthochromic in three. Thus, 75% of the patients with intracerebral hemorrhage had either grossly bloody or xanthochromic CSF, while in 25% the CSF was clear. In all four patients with clear CSF, pathological examination revealed the presence of intraparenchymal hemorrhage involving cortex and white matter with some leakage of blood into the overlying subarachnoid space. In these patients, lumbar punctures were performed on the day of onset in three and on the second day in one. Color was recorded in 24 of 27 patients with hemorrhagic infarction and was clear in 21, xanthochromic in two and cloudy in one. In 18 patients with ischemic infarction the color was clear in 15 and cloudy in one. Grossly bloody CSF was never encountered in patients with either hemorrhagic or ischemic infarction, but CSF was xanthochromic in two patients with hemorrhagic infarction.

The presence of red blood cells (RBCs) in the CSF is frequently used to differentiate patients with intracerebral hemorrhage from those with cerebral infarction (table 3). In four patients with intracerebral hemorrhage in whom the CSF was clear, the RBC counts were less than 3,000 per cubic millimeter (0, 72, 840, and 2,170 per cubic millimeter). None of the 18 patients with ischemic infarction had RBC counts greater than 500 per cubic millimeter. Figure 2 indicates that the color was grossly bloody or xanthochromic in all patients in whom the RBC counts were greater than 3,000 per cubic millimeter. RBC counts were available in four of five patients with xanthochromic CSF; in two of these, RBC counts were greater than 3,000 per cubic millimeter.
were greater than 3,000 per cubic millimeter. In the other two, RBC counts were 1,970 and two per cubic millimeter.

Table 4 shows the polymorphonuclear neutrophilic leukocyte (PNL) counts in 40 cases in which CSF was clear (four with intracerebral hemorrhage, 21 with hemorrhagic infarction, and 15 with ischemic infarction). PNLs were present in two of four patients with intracerebral hemorrhage, six of 21 with hemorrhagic infarction, and five of 15 with ischemic infarction. The numbers of PNLs were never greater than five per cubic millimeter except in one patient with cerebral hemorrhage in whom six per cubic millimeter were present. Lymphocytic leukocyte response in clear CSF was minimal (table 5). In one patient with clear CSF and hemorrhagic infarction, CSF lymphocyte count was six per cubic millimeter.

Table 6 lists the CSF protein values in those cases with clear CSF. All four cases with intracerebral hemorrhage and clear CSF had elevated CSF protein, ranging from 56 to 240 mg%. CSF protein was elevated in 13 of 21 cases with hemorrhagic infarction and in five of 15 with ischemic infarction. In two cases with hemorrhagic infarction, the protein values were greater than 100 mg% (118 and 137 mg%).

Table 7 shows CSF cell counts and protein values in patients with xanthochromic or cloudy CSF. In one patient with hemorrhagic infarction, RBC and leukocyte counts were both normal but CSF protein was elevated at 158 mg%. In this patient, the xanthochromic color was probably related to a high CSF protein level. It is interesting to note that in the patient with ischemic infarction, PNLs were markedly increased while RBC and lymphocyte counts and protein levels were only minimally elevated. A similar but less marked elevation of PNLs was frequently present in patients with xanthochromic or cloudy CSF.

Discussion

As expected, the gross appearance and RBC counts were the two most useful CSF parameters in differentiating cases with intracerebral hemorrhage from those with cerebral infarction. Grossly bloody CSF was always due to intracerebral hemorrhage. CSF pressures, protein values and leukocyte counts were less useful in differentiating intracerebral hemorrhage from cerebral infarction. Cases with hemorrhagic infarction could not be separated from those with ischemic infarction on the basis of CSF analysis.

In general agreement with other reports,1, 2, 25% of the patients with intracerebral hemorrhage (four of 16) had CSF which appeared to be clear. Autopsy examination in all four patients in this group showed one or more foci of intracerebral hemorrhage with leakage of blood into the overlying subarachnoid space. Lumbar punctures were performed within 24 hours of onset of symptoms in three cases and within 48 hours in the fourth. It is therefore possible that in these four patients lumbar punctures preceded the leakage of blood into the subarachnoid or ventricular spaces. In such situations, serial lumbar punctures might conceivably increase the probability of finding bloody CSF or increased RBC counts in patients with intracerebral hemorrhage. Subarachnoid blood in these four patients may have remained loculated in the
CSF IN CEREBRAL HEMORRHAGE AND INFARCTION

### TABLE 5

<table>
<thead>
<tr>
<th>Pathological diagnosis</th>
<th>Concentration of lymphocytes (#/mm³)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ICH</td>
<td>Hemorrhagic infarction</td>
</tr>
<tr>
<td>0</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>1-5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>&gt;5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>21</td>
</tr>
</tbody>
</table>

region overlying the cerebral hemispheres or may have been insufficient in quantity to grossly affect the color and RBC counts of the lumbar subarachnoid fluid.

It has been shown previously that CSF color is easily perceived as being grossly bloody when the RBC concentration is greater than 6,000 per cubic millimeter; at concentrations between 500 and 6,000 per cubic millimeter, the color is more often perceived as cloudy, xanthochromic or pink-tinged.10-12 Our results generally agree with these observations. In this study RBC counts in grossly bloody CSF were always greater than 4,000 per cubic millimeter (fig. 2).

However, as seen in table 7, RBC counts in xanthochromic or cloudy CSF were also occasionally greater than 6,000 per cubic millimeter.

Other studies1-5 have shown that CSF leukocytic reactions are common after acute cerebral hemorrhage or infarction and peak three to four days after onset.6 PNLs in the CSF may be increased sufficiently to simulate infection.3,5 In our study, patients with clear CSF had minimal PNL responses in their CSF; PNL counts were never greater than 20 per cubic millimeter. However, in xanthochromic or cloudy CSF, PNL and lymphocyte counts were frequently elevated, occasionally to high levels. In one patient the presence of cloudy CSF with a very high PNL count (table 7) resulted in the initiation of antibiotic therapy for suspected meningitis. Cultures of the CSF in this case were negative and at autopsy there was no evidence of meningitis.

As reported by others,1,3,5 elevated CSF protein levels are commonly present in intracerebral hemorrhage or cerebral infarction. In our study elevated CSF protein levels were present in 28 of 47 patients with clear, xanthochromic or cloudy CSF.

In agreement with other investigators,1-5 elevated opening pressures were more often seen in patients with either intracerebral hemorrhage or hemorrhagic infarction than in patients with ischemic infarction. In patients with cerebral infarction, CSF pressure may be elevated due to cerebral edema with or without transtentorial herniation. Although high lumbar CSF pressures were encountered more frequently in patients with intracerebral hemorrhage, two patients with infarction had CSF pressures greater than 300 mm CSF.

### TABLE 7

<table>
<thead>
<tr>
<th>Pathological diagnosis</th>
<th>CSF color</th>
<th>Protein (mg %)</th>
<th>Cell count/mm³</th>
<th>Protein (mg %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RBC</td>
<td>PNL</td>
<td>Lymph,</td>
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<tr>
<td>Hemorrhagic infarction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xanthochromic hemorrhage</td>
<td>15,360</td>
<td>150</td>
<td>50</td>
<td>472</td>
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<tr>
<td></td>
<td>1,970</td>
<td>136</td>
<td>0</td>
<td>127</td>
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<tr>
<td></td>
<td>390</td>
<td>18</td>
<td>30</td>
<td>242</td>
</tr>
<tr>
<td>Ischemic infarction</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>7,150</td>
<td>10</td>
<td>30</td>
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References

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