Computed Tomographic Findings of Good Prognosis For Hemiplegia in Hypertensive Putaminal Hemorrhage

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SUMMARY Computed tomography (CT) findings were analyzed in 17 patients with hypertensive putaminal hemorrhage accompanied by hemiplegia which had subsided almost completely by conservative therapy within one month after the onset. In such patients a high density area was not seen at the level of the lateral ventricles on CT scan. To study the reason for this, the relationship between the extent of a hematoma and the level at which the pyramidal tract was destroyed was investigated. From consideration of the process of destruction of the pyramidal tract by a hematoma, it seemed that CT findings at the level of the bodies of the lateral ventricles, rather than at the level of the posterior limb of the internal capsule, were of value in evaluating the prognosis of hemiplegia in putaminal hemorrhage.

The prognosis of hemiplegia is one of the most important factors in the formulation of early therapeutic policy for hypertensive intracerebral hemorrhage. In a previous study patients with putaminal hemorrhage, who demonstrated a "sign of sparing the internal capsule" on cerebral angiography, were reported to have a favorable prognosis not only for life but also for hemiplegia. Since the introduction of computed tomography (CT) precise information on the location and extent of hematoma is possible. A characteristic feature of CT findings in those patients with putaminal hemorrhage, where there is marked improvement of hemiplegia, is non-visualization of the hematoma on CT scans at the levels of the lateral ventricle bodies. In this study an attempt was made to define the reason why the hemiplegia in these patients followed a favorable course by investigating the relationship between the extent of a hematoma caused by putaminal hemorrhage and the level at which the pyramidal tract is destroyed.

Material
Forty-five patients with putaminal hemorrhage were admitted to the Institute of Brain and Blood Vessels, Mihara Memorial Hospital, from April, 1976, through March, 1977. CT and cerebral angiography was performed within 2 weeks after onset in all patients. This report covers 17 (37.8%) of those 45 patients in whom almost complete recovery from hemiplegia was achieved with conservative therapy within 1 month after onset (table).

Methods
1. Method of Scanning
A CT-H (Hitachi) scanner was used for this investigation. Three to 4 serial brain slices of 10 mm thickness parallel with the orbitomeatal line were scanned upward from 3 cm above that line.

Results
1. Location of Posterior Limb of Internal Capsule in 23 Autopsied Brains Without Lesions
The lateral margin of the genu of the internal capsule (A) was found to be situated an average of 0.9 ± lateral to the median point (M) of the line joining the posterior margin of the bilateral foramina of Monro. The posterior end of the putamen (B) was located an average of 3.0 (SD ± 0.1) cm lateral (PC) and an average of 0.9 (SD ± 0.2) cm anterior (BC) to the center of the pineal body (P) (fig. 1).

A hypothetical line joining A and B is arbitrarily defined as the lateral line of the posterior limb of the internal capsule. The positional relationship between this line and the hematoma in 17 patients studied was analyzed on CT scans in which the foramen of Monro and the pineal body were clearly demonstrated.

2. Relation between Defined Line of Posterior Limb of Internal Capsule and Hematoma
There were 6 patients with a hematoma found not to have extended beyond the line of the posterior limb of the internal capsule (fig. 2).
TABLE  Seventeen of 45 Patients with Recovery from Hemiplegia within One Month

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Age</th>
<th>Sex</th>
<th>Onset 1 CT</th>
<th>Disturbance of Consciousness</th>
<th>Aphasia</th>
<th>Motor Disturbance of Upper Extremity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Y.M.</td>
<td>73</td>
<td>female</td>
<td>14 days</td>
<td>stupor</td>
<td>?</td>
<td>1-2</td>
</tr>
<tr>
<td>2</td>
<td>K.I.</td>
<td>59</td>
<td>male</td>
<td>5 days</td>
<td>drowsy</td>
<td>(—)</td>
<td>2-3</td>
</tr>
<tr>
<td>3</td>
<td>N.K.</td>
<td>45</td>
<td>male</td>
<td>9 days</td>
<td>drowsy</td>
<td>(—)</td>
<td>1-2</td>
</tr>
<tr>
<td>4</td>
<td>I.K.</td>
<td>36</td>
<td>male</td>
<td>2 days</td>
<td>drowsy</td>
<td>(—)</td>
<td>4-5</td>
</tr>
<tr>
<td>5</td>
<td>T.Y.</td>
<td>58</td>
<td>male</td>
<td>3 hours</td>
<td>alert</td>
<td>(—)</td>
<td>1-2</td>
</tr>
<tr>
<td>6</td>
<td>M.M.</td>
<td>49</td>
<td>male</td>
<td>5 days</td>
<td>drowsy</td>
<td>(—)</td>
<td>3-4</td>
</tr>
<tr>
<td>7</td>
<td>J.H.</td>
<td>57</td>
<td>male</td>
<td>13 days</td>
<td>drowsy</td>
<td>(—)</td>
<td>3-4</td>
</tr>
<tr>
<td>8</td>
<td>S.O.</td>
<td>68</td>
<td>male</td>
<td>3 days</td>
<td>alert</td>
<td>(—)</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>M.M.</td>
<td>63</td>
<td>male</td>
<td>24 hours</td>
<td>stupor</td>
<td>(—)</td>
<td>2-3</td>
</tr>
<tr>
<td>10</td>
<td>T.M.</td>
<td>41</td>
<td>female</td>
<td>15 hours</td>
<td>drowsy</td>
<td>(+)</td>
<td>0-1</td>
</tr>
<tr>
<td>11</td>
<td>K.H.</td>
<td>59</td>
<td>female</td>
<td>5 days</td>
<td>alert</td>
<td>(—)</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>S.S.</td>
<td>59</td>
<td>female</td>
<td>3 hours</td>
<td>drowsy</td>
<td>(—)</td>
<td>0-1</td>
</tr>
<tr>
<td>13</td>
<td>V.G.</td>
<td>63</td>
<td>male</td>
<td>7 days</td>
<td>drowsy</td>
<td>(—)</td>
<td>4</td>
</tr>
<tr>
<td>14</td>
<td>F.I.</td>
<td>47</td>
<td>male</td>
<td>6 hours</td>
<td>drowsy</td>
<td>(—)</td>
<td>3</td>
</tr>
<tr>
<td>15</td>
<td>K.A.</td>
<td>47</td>
<td>male</td>
<td>2 days</td>
<td>alert</td>
<td>(—)</td>
<td>4-5</td>
</tr>
<tr>
<td>16</td>
<td>R.K.</td>
<td>61</td>
<td>female</td>
<td>11 hours</td>
<td>drowsy</td>
<td>(—)</td>
<td>3</td>
</tr>
<tr>
<td>17</td>
<td>M.H.</td>
<td>77</td>
<td>male</td>
<td>3 days</td>
<td>drowsy</td>
<td>(—)</td>
<td>2</td>
</tr>
</tbody>
</table>

Eleven patients had a hematoma which extended beyond the line (fig. 3).

3. Presence or Absence of Hematoma at Levels of Bodies of Lateral Ventricles

Hematoma was undemonstrable in 15 patients (fig. 4)

Hematoma was demonstrable in 2 patients (fig. 5)
In these latter 2 patients a hematoma was demonstrable only to a slight extent in an area of the white matter corresponding to the anterior half of the body of the lateral ventricle.

Four patients had clear consciousness, 11 were drowsy and 2 were stuporous at the onset. None of the 17 patients were semi-comatose or comatose. All had

**Figure 1.** $\overline{MA} = 0.9 (sd \pm 0.2) \text{cm}$, $\overline{FC} = 3.0 (sd \pm 0.1) \text{cm}$, $\overline{BC} = 0.9 (sd \pm 0.2) \text{cm}$, $\overline{AB} = \text{posterior limb of the internal capsule}$, $M = \text{median point of the line jointing the two interventricular foramina}$, $P = \text{pineal body}$, $A = \text{lateral margin of the genu of the internal capsule}$, $B = \text{posterior end of the putamen}$.

**Figure 2.** The projected internal capsule (dotted line) is not destroyed by hematoma on CT scan.
hemiplegia at onset — 2 complete and 15 incomplete (table).

Discussion

It has been claimed that the prognosis of hemiplegia in hypertensive cerebral hemorrhage depends primarily upon whether or not the posterior limb of the internal capsule is destroyed by the hematoma.1-3 There is a report stating that the CT scan delineates the posterior limb of the internal capsule by the difference in the x-ray absorption coefficient between the white and grey matter.4 However, where putaminal hemorrhage exists, the posterior limb of the internal capsule may not always be clearly visualized on CT. This difficulty prompted us to analyze CT findings in putaminal hemorrhage. The spatial relationship of the hematoma to the posterior limb of the internal capsule, represented by a line called the line of the posterior limb of the internal capsule, defined by us on the basis of measurements of autopsied brains, was studied. The results indicate that in 11 of the 17 patients the hematoma extended beyond that line. The posterior limb of the internal capsule appeared on CT as if it had been destroyed. From the fact that there was marked improvement in the hemiplegia (Grade 4 or 5 in both the upper and lower extremities) in all 17 patients, it seems that the posterior limb of the internal capsule actually was not destroyed. Since in putaminal hemorrhage the posterior limb of the internal capsule is likely to be displaced medially by the pressure of a hematoma, it is difficult to determine from CT scans at this level whether or not the posterior limb of the internal capsule is actually destroyed. CT scans at the levels of bodies of the lateral ventricles also shows a small high density area.

FIGURE 3. The projected internal capsule (dotted line) is destroyed by hematoma on CT scan.

FIGURE 4. CT scan of patient No. 6. Left: CT scan at the level of the foramen of Monro shows high density area in the putamen. Right: CT scan at the level of the bodies of the lateral ventricles shows on high density area.

FIGURE 5. CT scan of patient No. 12. Left: CT scan at the level of the foramen of Monro shows high density area in the putamen. Right: CT scan at the level of the bodies of the lateral ventricles also shows a small high density area.
lateral ventricles were analyzed for the presence of hematoma. At this level, hematomas were not demonstrable in 15 of 17 patients.

It seemed relevant to study the process of destruction of the pyramidal tract by an advancing hematoma in putaminal hemorrhage. In figure 6 a triangle is indicated by dotted lines projected on a coronal section which passes through the posterior half of the posterior limb of the internal capsule. The top line extends from the stria terminals to the upper margin of the insula. The line from the upper margin of the putamen to the stria terminals forms the inferomedial leg of the triangle. The third line extends from the upper margin of the putamen to the insula. This triangle was proposed on the basis of the following anatomical facts:

1. The upper margin nearly corresponds to the level of the floor of the body of the lateral ventricle.
2. The outermost fibers of the pyramidal tract pass along the inferolateral margin of this triangle to the posterior half of the posterior limb, internal capsule.
3. The inferomedial margin represents the upper end of the posterior limb of the internal capsule.

The hematoma of putaminal hemorrhage is apt to advance to the area of distribution of the lateral branch of the striate artery, namely, in the direction indicated by the arrow in figure 6. During this advancement those fibers of the pyramidal tract which run through the triangle are first affected. For this reason, the triangle may well be termed the "vulnerable triangle" in putaminal hemorrhage. Figure 7 shows a schematic representation of the relation between the extent of hematoma on CT scan and the triangle. The top drawing gives the situation in 15 patients (exclusive of patients No. 12 and No. 13) in the table. The hematoma is as yet short of the triangle and the pyramidal tract is very likely to remain unaffected. This accounts for the failure to visualize hematoma on CT scans at the level of the bodies of the lateral ventricles.

The middle drawing illustrates an instance in which the vulnerable triangle has been partially destroyed by a hematoma progressing upward. The hematoma has extended beyond the upper margin of the triangle and

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**Figure 6.** Schematic drawing of the pyramidal tract, the ventricle and the basal ganglia. The triangle indicated by dotted lines is vulnerable to hematoma. We have named it the "vulnerable triangle." Hematoma tends to advance in the direction of the black arrow. C = caudate nucleus; T = thalamus; P = putamen; V = body of the lateral ventricle.

**Figure 7.** The correlation of "vulnerable triangle" with the advancement of hematoma. Upper Part: Hematoma is localized lateral to the putamen. "Vulnerable triangle" is not affected. Center Part: Hematoma progresses into "vulnerable triangle" and destroys it partially. Lower Part: "Vulnerable triangle" is destroyed completely and hematoma progresses into the body of the lateral ventricle, destroying the internal capsule.
can, therefore, be clearly demonstrated on CT scans at the level of the bodies of the lateral ventricles. This anatomical situation accounts for 2 of the 17 patients (Nos. 12 and 13) in which a hematoma was barely visible in an area of the white matter at the level of the anterior half of the body of the lateral ventricle. In these 2 patients improvement of hemiplegia was somewhat delayed.

The bottom drawing shows a hematoma which has destroyed the vulnerable triangle and the posterior limb of the internal capsule and has perforated the body of the lateral ventricle.

On the basis of the mechanism of hematoma advancement, we have analyzed CT scans of 28 patients with putaminal hemorrhage in which there was little clinical improvement (Grade 2 or 3 in both the upper and lower extremities) of hemiplegia. Perforation of the ventricle was noted in 18 of these 28 patients but not in the remaining 10. A hematoma was clearly demonstrated at the level of bodies of the lateral ventricles in all 28. The extent of hematoma at the level of the posterior limb of the internal capsule in 10 patients without perforation of the ventricle was not always larger than in the present series of 17 patients showing a favorable improvement of hemiplegia.

From consideration of the process of destruction of the pyramidal tract by a hematoma in putaminal hemorrhage, it is obvious that CT scans at the level of the bodies of the lateral ventricles, rather than at the level of the posterior limb of the internal capsule, are of value in determining the prognosis of hemiplegia attending putaminal hemorrhage.

References
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doi: 10.1161/01.STR.12.5.648

*Stroke* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0039-2499. Online ISSN: 1524-4628

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