The Use of Echoencephalography to Differentiate Intracerebral Hemorrhage and Brain Softening

HARUYUKI KANAYA, M.D., HIDEO YAMASAKI, M.D., IWAO SAIKI, M.D.,
AND KOICHIRO FURUKAWA, M.D.

Department of Surgery, Iwate Medical University School of Medicine, Morioka, Japan

ULTRASOUND WAVE was first used in the diagnosis of intracranial disease by Dussik in 1942 when he applied an ultrasonic transmission method. In recent years a reflection method has been used with excellent results. Ultrasonic diagnosis of intracranial disease is based on the observation of the shift of the midline echo, which corresponds with the reflected echo of the midline structure, as well as on the observation of the reflected echo derived from the intracranial lesion itself.

We have found in our surgical treatment of hypertensive intracerebral hemorrhage that it has often been difficult to differentiate intracerebral hemorrhage from cerebral softening. In intracerebral hemorrhage the echogram shows a midline echo shift whereas in cerebral softening there is none. We have found, however, that when the hematoma is small enough not to produce a midline echo shift, the hematoma echo with its multiple spike-like pattern derived from hematoma itself is a better diagnostic guide. We are now reporting our experiences with echoencephalography in the differential diagnosis of intracerebral hemorrhage, cerebral softening, and subarachnoid hemorrhage.

Method

An Aloka SSD-2 apparatus (Japan Radio Company Ltd., Tokyo) of the reflection type was used, with barium titanate 10 mm in diameter as the transducer. The best frequency for registering the hematoma echo appeared to be 2.25 mc. The transducer was placed over the temporal scalp, and records were made from the normal side as well as that of the lesion.

During operation a special transducer was placed over the dura to determine by echo pattern the depth, location, and extent of the hematoma from the cortex. This was done through the same 4 cm frontal or temporal trephine opening used to evacuate the hematoma. Postoperative examination, done the same way as the preoperative study, registered the echo pattern and change in the midline echo shift following removal of the hematoma.

Cases with Hypertensive Intracerebral Hemorrhage

Only those patients in whom the size and location of the hematoma were confirmed by surgery or autopsy were included in this study. There were 61 patients ranging in age from 38 to 75 years; 43 were men and 18 women, 52 with supratentorial hemorrhages and 9 with infratentorial hemorrhages. The earliest case was examined 6 hours after the attack, with 55 cases being examined within 7 days.

Supratentorial Hemorrhage. 1. Preoperative scalp echoencephalogram. Of 52 cases with supratentorial hemorrhage, 49 (94%) showed a hematoma echo with a multiple spike-like pattern. Midline echo shift (Fig. 1) was positive in 43 patients (83%) and negative in 9 (17%). There were no false positive cases. Of

Fig. 1. Preoperative scalp echoencephalogram of hypertensive intracerebral hemorrhage. This 71-year-old man was admitted with disturbance of consciousness and hemiplegia on the left side. Examination made on the 3rd day after attack showed a hematoma echo with a midline shift. (HE=hematoma echo; ME=midline echo.)
nine cases with no midline shift, three were false negative.

2. Preoperative dural echoencephalogram. Epidural examinations were done in 28 cases. In all of these cases the hematoma echo was sharper than that in the scalp recording (Fig. 2). The distance between the dura and the hematoma determined from the hematoma echo and actual exploration was compared in 20 cases; the error was less than 5 mm in 11 cases (55%) and within 6 to 10 mm in three cases (15%). No error more than 11 mm was recorded.

3. Postoperative scalp echoencephalogram. Postoperative echogram was recorded in a similar manner as the preoperative examination, over the temporal scalp. In 21 cases, changes in the midline echo shift and hematoma echo were followed periodically (Fig. 3); the midline echo shift was reduced on the first postoperative day, improved appreciably within 3 days, and returned to normal within several days. The hematoma echo was somewhat reduced on the first day and was more simplified in pattern up to 7 days; the interval of the echo was also decreased. Within 2 to 3 weeks the hematoma echo disappeared and became a single spike, which persisted afterwards in some cases.

Infratentorial Hemorrhage. Seven of nine cases in this group had pontine hemorrhage with rupture into the fourth ventricle, one had a pontine hemorrhage with bleeding into the cerebellum, and one had a cerebellar hemorrhage. A midline echo shift was noticed in only one case and was negative in the remaining eight. A hematoma echo was noticed in three and not in the remaining six.

Cases with Brain Softening

A total of 35 cases comprising 23 men and 12 women aged 43 to 78 years was examined. Seven cases were in an acute and 28 in a chronic stage. They were diagnosed as having
brain softening on the basis of neurological tests, electroencephalogram, lumbar puncture, and cerebral angiography. In two cases, autopsy confirmed the diagnosis. There was a midline echo shift in only two cases (6%); it was not found in 33 cases (94%). A simple spike-like echo pattern derived from the ione was seen in five cases (14%), the remaining cases showing no pathological echogram (Fig. 4).

**Cases with Subarachnoid Hemorrhage**

This group had eight cases, six men and two women aged 30 to 66 years. Aneurysmal rupture in three cases and primary subarachnoid hemorrhage in five cases were the causes. A midline echo shift was noticed in two of the eight cases (25%). No cases showed an abnormal echo from the bleeding.

**Discussion**

Midline echo shift has been regarded as the important sign in the echoencephalographic differential diagnosis between hypertensive intracerebral hemorrhage and brain softening (Taylor, *et al.*, and Jeppson). We have found a hematoma echo with a multiple spike-like pattern derived from the intracerebral hematoma; this has made possible a more accurate differentiation.

**Midline Echo.** In the diagnosis of an intracranial mass lesion the placement in the midsagittal plane is the important sign. The midline echo (ME) in the echoencephalogram is derived from the midline structure. The sources of the ME are variously interpreted by different authors. Vlieger and Ridder believed that it was derived from the third ventricle, Leksell ascribed it to the pineal body, Vlieger and Ridder to the interhemispheric fissure, and Lighthander to the septum pellucidum and midbrain aqueduct. Kanaya felt that all these structures could be the echo sources depending on the site and angle of the probe during examination.

Physiological range of ME shift is 3 mm, according to Taylor, *et al.*, while Jefferson believes that a shift up to 2.2 mm is normal. In our series of 100 healthy adults, the average shift was 0.3 ± 0.24 mm with a maximum shift of 1 mm.

In our cerebral apoplectic cases a ME shift of more than 1 mm was interpreted as pathological. This criterion was found valid in 100 of 104 cases of apoplexy confirmed by cerebral angiography, surgery, or autopsy. The diagnostic accuracy of the ME shift was generally good, as noted by other authors: Vlieger, 95% accuracy; Taylor, 91%; Ford, 95.8%; Jefferson, 90%; and Jeppson, 97.9 ± 0.6%.

**Hematoma Echo.** The diagnosis of intracerebral hemorrhage is made possible by detection of a multiple spike-like pattern derived from the intracerebral hematoma. The diagnostic validity of the hematoma echo (HE) in the differentiation from brain softening was described at the First Meeting of the Japan Society of Ultrasonics in Medicine, held in May, 1962. The HE can be recorded in freshly autopsied brains, in intracerebral hematomas in dogs, and in clinical cases.

On the other hand, brain softening in the dog and the human case do not cause a multiple spike-like pattern in the echogram. Experimental and surgical findings proved that HE is derived from a clot in the fluid blood, grossly damaged brain tissues, or the inter-surface between hematoma and brain tissue. In our experience the multiple spike-like pattern disappeared within 2 to 3 weeks after removal of the hematoma. Our observation has been further investigated by Sugar and Uematsu, Tanaka and Ito, and Nagai, *et al.* The HE was seen in 49 of 52 cases (94%) with supratentorial hypertensive intracerebral hemorrhage.
**Diagnostic Value in Cerebral Apoplexy.** In 104 cases echoencephalography was performed. There was a ME shift in 48 cases, 44 of which (92%) had intracerebral hemorrhage. Thus, when ME shift is found in an apoplectic case, intracerebral hemorrhage is likely. On the other hand, nine of 52 supratentorial hemorrhage patients (17%) had no ME shift, whereas positive ME shift was noticed in 6% of cases with brain softening and 25% of those with subarachnoid hemorrhage. It appears that the presence of ME alone does not justify the diagnosis of apoplexy.

The HE was found in 49 of 52 cases (94%) with supratentorial hemorrhage, but in none of those with brain softening or subarachnoid hemorrhage. Moreover, HE was seen in seven of nine cases of supratentorial hemorrhage in whom ME shift was not seen; thus the hematoma echo established the diagnosis of intracerebral hemorrhage. Ford and Ambrose\(^3\) differentiated intracerebral hemorrhage and subarachnoid hemorrhage on the basis of ME shift and the size of the lateral ventricle as registered in the echogram. Achar, et al.,\(^1\) also made the diagnosis on the basis of ME shift.

It should be considered, however, that when a mass lesion is small the ME shift may not be seen, while it can be seen in brain softening when swelling of a cerebral hemisphere is produced. Thus, ME shift alone cannot accurately differentiate the cause of apoplexy. Detection of HE is then necessary.

**Hematoma Volume.** The volume of hematomas in 52 cases of supratentorial hemorrhage ranged from 10 to 350 cc. Table 1 shows the relation of hematoma volume to ultrasonic findings. When the hematoma contained from 31 to 90 cc there was a ME shift in 22 of 25 cases (88%). In our series the displacement in this group was equally divided between the 1.1 to 2.0 mm and 2.1 to 3.0 mm ranges. When the hematoma content exceeded 91 cc, all cases except one that was falsely diagnosed showed a ME shift; 78% of these cases had 2.1 to 3.0 mm displacement. The HE was demonstrated in 67% of the cases in which the volume of hematoma was less than 10 cc, in 78% with 11 to 30 cc, and in 100% with more than 31 cc.

**Displacement of the Anterior Cerebral Artery and ME Shift.** Cerebral angiography was done in 46 of 52 cases with supratentorial hemorrhage. The relationship between the displacement of the anterior cerebral artery and ME shift is shown in Table 2. Displacement of the anterior cerebral artery was seen in three of eight cases in which there was no ME shift. In these three cases the extent and site of the hematoma suggested that the negative ME shift was due to false evaluation of the echogram or technical error. Of 12 cases in which there was no displacement of the anterior cerebral artery, seven had ME shift. Thus, the diagnostic accuracy of ME shift was superior to that based on displacement of the anterior cerebral artery.

**Table 1**

<table>
<thead>
<tr>
<th>Midline Echo Shift (mm)</th>
<th>Hematoma Volume (cc)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 10</td>
<td>11/30</td>
<td>50/70</td>
</tr>
<tr>
<td>0-1.0</td>
<td>4/1</td>
<td>1/1</td>
</tr>
<tr>
<td>1.1-2.0</td>
<td>1/4</td>
<td>4/4</td>
</tr>
<tr>
<td>2.1-3.0</td>
<td>1/1</td>
<td>1/4</td>
</tr>
<tr>
<td>2/3</td>
<td>78%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Echoencephalography of Intracerebral Hemorrhage

TABLE 2
Relation of midline echo shift to displacement of the anterior cerebral artery

<table>
<thead>
<tr>
<th>Midline Echo Shift (mm)</th>
<th>Displacement of the Anterior Cerebral Artery (mm)</th>
<th>Positive Displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1–5</td>
</tr>
<tr>
<td>0–1.0</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>1.1–2.0</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>2.1–3.0</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Positive Shift</td>
<td>7/12</td>
<td>10/10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hematoma Echo</td>
<td>10/10</td>
<td>10/10</td>
</tr>
<tr>
<td></td>
<td>83%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Summary

We have found that echoencephalography is a particularly reliable way to determine the origin of cerebral apoplexy in a specific individual. The characteristic multiple spike-like pattern in the echogram of the hematoma itself could be demonstrated by both scalp and dural approaches. The sources of the hematoma echo appeared to be a clot in fluid blood, cerebral tissue debris, or the ragged interface between hematoma and brain. The hematoma echo could be demonstrated in both clinical and experimental intracerebral hematomas. In brain softening, however, no abnormal echo could be seen.

Dural echoencephalography performed during surgery for supratentorial hemorrhage always demonstrated a hematoma echo and thus facilitated detection of the hematoma.

References

9. KANAYA, H. Studies on normal echoencephalography, especially interrelation with topographic neuroanatomy. 8th Meeting of the Japan Society of Ultrasoundsc in Medicine, Hiroshima, Nov., 1965.