Echoencephalography as an Aid to the Diagnosis of Space-Occupying Lesions in the Posterior Fossa by Measuring the Size of the Third and Lateral Ventrices*

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Since 1955 when echoencephalography was first used by Leksell as a procedure to lateralize a space-occupying supratentorial mass, it has gained wide application through the world. The possibilities for diagnosing tumors in the posterior fossa or abnormalities of the aqueduct of Sylvius are much less well known.

Even Leksell in his first publication on echoencephalography presumed that the ventricular walls would also reflect ultrasound. In 1959, de Vlieger and Ridder obtained echoencephalograms with a double reflection from the lateral walls of the third ventricle. In 1961, Lithander was able to diagnose enlargement of the ventricular system in children using ultrasound. Jeppsson in his monograph of 1961 was of the opinion that the echo method was not of value with posterior fossa lesions. Even within the last 2 years, reports have been published that do not recognize the value of A-scan echoencephalography with such lesions. Investigations using B-scan to demonstrate the enlarged lateral ventricles have been performed only rarely.

Methods

The use of A-scan echoencephalography for measuring the width of the third ventricle is not limited to children and juveniles with a thin skull bone. In adults, also, the sonic energy reflected from the boundaries between the ventricular walls and the cerebrospinal fluid is sufficient to penetrate the skull bone in the temporal region and to give usable reflections on the cathode-ray tube screen, especially in the case of an enlarged ventricular system with the ultrasonic beam striking the boundaries vertically. In many cases, the reflections of the third ventricle walls have a higher amplitude than that of the calcified pineal body. We are reporting a series of 484 echoencephalograms made on 156 patients, mostly adults, who had tumors of the posterior fossa or chronic stenosis of the aqueduct (Fig. 1).

The technique of A-scan echoencephalography is illustrated in Fig. 2. The probe is first applied directly above the ear (Position 1); the double reflection of the third ventricle becomes visible, and the distance between the two echoes corresponds to the diameter of the third ventricle. The probe is then directed a little downward (Position 2) so that reflections are also obtained from the temporal horn. In most cases, the lateral wall of this ventricle produces the higher echo because of the concavity of the reflecting plane. The probe is then placed 12 cm above the ear (Position 3), to receive the midline echo from the posterior part of the septum pellucidum or from the calcified pineal body.

The position of the temporal-horn echo on the ultrasonogram represents a good standard for the degree of ventricular enlargement. To simplify the evaluation of echoencephalograms in patients with dilated ventricles, we defined a brain-mantle-index.
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Fig. 2. Echoencephalographic investigation technique in cases of hydrocephalus: 1) measurement of the third ventricle (3.V.), 2) measurement of the opposite temporal horn (TH), 3) measurement of the midline structures (M).

(BMI), based on the distance from the midline echo to the end echo related to the distance from the lateral temporal horn echo to the end echo (Fig. 3). We then paired the degree of ventricular dilatation to the brain mantle index in each case, and found an index rate of 2.2 to be normal (Fig. 4). Posterior fossa tumors caused average rates of 2.6 to 3.2. Higher rates were unusual and were observed only in infants and patients with occlusion of the aqueduct. The good agreement between the BMI measurements and the width of the third ventricle as determined by the echograms is shown in Fig. 5.

We also checked the exact agreement between echoencephalographic and pneumoencephalographic measurements by measuring the diameter of the third ventricle by the two methods in 56 cases (Fig. 6). The measurements of the ventriculogram were 25 to 35% larger than those of the echogram, probably due to the dispersion of x-rays. The ultrasonic investigations were carried out 1 or 2 days before the operative ventriculography. It is evident that echoencephalography is a reliable method of measuring the width of the third ventricle. Complete conformity was also found when comparing echoencephalograhic results with brain specimens in some postmortem studies.

The same results were true for the measurement of the temporal horn echo. Ventriculotomograms checked against the echoencephalograms of the same patients showed that the high reflections before the end echo correspond to the lateral wall of the temporal horn (Fig. 7).

Results

Since 1962 we (Neurosurgical Department of Erlangen-Nuremberg University) have taken echoencephalograms in more than 2,500 patients with cerebral diseases and brain injuries. Among these were 156 pa-

Fig. 3. Evaluation of the echoencephalographic brain-mantle-index (BMI): M = midline echo, E = end echo, a = distance between midline echo to end echo, b = distance between lateral temporal horn echo to end echo.
patients with a tumor in the posterior fossa or with chronic stenosis of the aqueduct; 484 echograms were performed on patients in this group. The “Siemens-Krautkrämer-Echoencephalograph” with a barium titinate transducer of 15 mm diameter and a frequency of 2.0 Mc/s was used. Ultrasonograms displayed on the screen of the cathode-ray tube were recorded with a Polaroid Land Camera on Polascope film type 410.

Preoperative Examinations

In 150 patients, preoperative ultrasonic investigations were performed before angiography or pneumoencephalography (Table 1). In 148 of these patients, we succeeded in determining the cerebral midline position by registration of the midline echo; there was no shift of the midline echo in 143 and a slow displacement of the M-echo, 4.0 mm at the most, in five. Of the five patients showing displacement, one had had a cerebellar metastastic occipital hypernephroma removed 4 months before, one had metastasis of a breast carcinoma in the right temporal lobe and an additional tumor in the cerebellum, and three had tumors in the cerebellopontine angle extending also into the supratentorial space (2 acoustic neurinomas, 1 meningioma). In two of the 150 patients, a definite midline echo could not be obtained (1 meningioma of the clivus, 1 acoustic neurinoma).

The width of the third ventricle could be measured in 147 patients (98.0%). The third ventricle was dilated 136 times (90.7%), that is, the distance between the two reflections of the double echo from the third ventricle expressed in terms of tissue was more than 7 mm. Eleven cases, mostly patients with tumors of the cerebellopontine angle, showed normal width of the third ventricle.

The width of the third ventricle measured by echoencephalography in 147 patients with a space-occupying lesion of the posterior fossa is demonstrated in Fig. 8. Cerebellar tumors and aqueductal stenosis were associated with third ventricles up to 26 mm in di-

![Fig. 4. Schematic presentation of the ventricular width in different values of the brain-mantle-index (large numbers). The small numbers indicate the width of the third ventricle in millimeters.](image)

![Fig. 5. Relation between the width of the third ventricle in the echogram and the brain-mantle-index (163 measurements).](image)
Fig. 6. Comparison between the width of the third ventricle in the echoencephalogram (black column) and the ventriculogram (white total column). With the usual x-ray technique, the third ventricle in the ventriculogram is 25 to 35% larger than in the echogram, which shows the actual size of the third ventricle.

Fig. 7. Similarity of the temporal horn echo in the ultrasonogram (TH) and the temporal horn in a ventriculotomogram of a 9-year-old girl with cerebellar medulloblastoma.

Fig. 8 Width of the third ventricle in the echogram with space-occupying lesions in the posterior fossa (147 cases).
Echoencephalography

ameter, 14.4 mm on an average. In acoustic neurinomas, the average diameter was 10.0 mm. The width of the third ventricle was normal in some cases, namely, in one meningioma of the posterior fossa, one arachnitis, one tumor of the brain stem, and five acoustic neurinomas.

Case Reports

We will use three cases to demonstrate the value of echoencephalography in the diagnosis of space-occupying lesions in the posterior fossa.

Case 1. Carmela B., a 30-year-old woman, gave birth to a healthy baby on January 7, 1963, and after an uncomplicated confinement was sent home. Three days later she suffered attacks of severe headache, especially in the occipital region. On admission to our hospital on January 25, 1963, she had slight neck stiffness and paralysis of the left abducens nerve. No cerebellar signs were present. There was bilateral papilledema. Lumbar puncture revealed clear, slightly xanthochromic fluid; protein was 26 mg%. A postpartum thrombosis of cerebral veins was suspected.

During the echoencephalographic examination, we found a double midline echo with a distance of 14.0 mm between the two reflections (Fig. 9). We had never seen such a

TABLE 1

Results of echoencephalography in 150 patients with space-occupying lesions of the posterior fossa

<table>
<thead>
<tr>
<th>Lesion</th>
<th>No. of Patients</th>
<th>M-Echo Normal</th>
<th>M-Echo Shifted</th>
<th>M-Echo not Obtainable</th>
<th>3rd Ventr. Normal</th>
<th>3rd Ventr. Dilated (&gt;7 mm)</th>
<th>3rd Ventr. not Measurable</th>
<th>Measurement of Temporal Horn Echo</th>
<th>Average Width of 3rd Ventricle (mm)</th>
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<tr>
<td>Cerebellar tumor</td>
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<td>62</td>
<td>—</td>
<td>2</td>
<td>4</td>
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<td>7</td>
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<td>1</td>
<td>9</td>
<td>9</td>
<td>2</td>
<td>4</td>
<td>11.0</td>
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<tr>
<td>Cerebellar metastasis</td>
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<td>7</td>
<td>2</td>
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<td>—</td>
<td>9</td>
<td>—</td>
<td>6</td>
<td>11.6</td>
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<tr>
<td>Acoustic neurinoma</td>
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<td>33</td>
<td>2</td>
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<td>5</td>
<td>29</td>
<td>2</td>
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<td>1</td>
<td>6</td>
<td>—</td>
<td>4</td>
<td>11.1</td>
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<td>Aqueduct stenosis</td>
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<td>18</td>
<td>—</td>
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<td>18</td>
<td>—</td>
<td>—</td>
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<td>3</td>
<td>6</td>
<td>—</td>
<td>3</td>
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<tr>
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<td>5</td>
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<td>11</td>
<td>136</td>
<td>3</td>
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<td>7.3</td>
<td>90.7</td>
<td>2.0</td>
<td>64.0</td>
<td>96.0</td>
</tr>
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</table>

Fig. 9. Echoencephalograms and ventriculogram in a 30-year-old woman with cerebellar angioblastoma. The double echo indicates an enlarged third ventricle (lower trace).
finding before. We thought that the double reflection must have come from the lateral walls of the third ventricle and therefore suspected a dilated third ventricle. With the diagnosis of occlusive hydrocephalus, operative ventriculography was performed and the dilatation of the ventricular cavities was confirmed. During posterior fossa exploration on February 15, 1963, a cystic angioblastoma was removed. Recovery was complete.

Case 2. Klaus L., a 9-year-old boy, was admitted to the hospital on November 11, 1965, because of vomiting, pains in the back of the neck, and an oblique bearing of the head. The neurological findings at this time were normal. The echoencephalographic examination revealed a normally situated midline echo (Fig. 10 A). A double reflection indicated a third ventricle diameter of 15.0 mm (Fig. 10 B). The position of the lateral temporal horn echo resulted in an echoencephalographic BMI of 2.72, indicating a distinct dilatation of the lateral ventricles (Fig. 10 C). This finding was confirmed by ventriculography. The form of the aqueduct pointed to a cerebellar tumor. The posterior fossa was explored, and a medulloblastoma was removed from the left cerebellar hemisphere.

Case 3. Ida Sch., a 59-year-old woman, was admitted to our hospital on January 4, 1966, because of unsteady walking and vomiting from time to time. The neurological examination revealed nystagmus, hypacusia on the left side, ataxia, and dysdiadochokinesia. Papilledema was not present. The echoogram showed pronounced ventricular enlargement, and vertebral arteriography disclosed an angioblastoma in the left cerebellar hemisphere (Fig. 11).

Postoperative Examinations

Echoencephalography is also a valuable procedure in the postoperative phase, for it makes possible for the first time the monitoring of the width of the ventricular system after an operation in the posterior fossa. Postoperative ultrasonic examinations were performed on 87 patients. In some cases the width of the third ventricle was measured daily for the first 2 weeks after posterior fossa exploration. In the other cases, echo-encephalographic follow-up studies were carried out 4 weeks to 6 years after the operation. In 74 patients, we had made preoperative ultrasonic measurements. Therefore, it was possible to compare preoperative measurements with the ventricular width after restoration of normal cerebrospinal fluid flow. The results were surprising. It is remarkable how much the third ventricle can

![Fig. 10. Ultrasonograms in a 9-year-old boy with medulloblastoma of the left cerebellar hemisphere. A. Midline echo in normal position. B. Double echo from the walls of the third ventricle at a distance of 15 mm. C. The position of the temporal horn echo on the screen indicates a distinct dilatation of the lateral ventricles with a BMI of 2.72.](image-url)
Fig. 11. Echogram showing a dilated third ventricle (15 mm diameter) and vertebral arteriogram in a 59-year-old woman with an angioblastoma.
shrink even in the first few days. In this connection, a distinct dependence of the ventricular width upon the pressure of the cerebrospinal fluid was evident. In several cases, an immediate narrowing of the third ventricle by 1 to 2 mm could be observed during lumbar puncture.

The decrease in third ventricular dilatation in the first 6 months after removal of a cerebellar tumor averaged 5.6 mm. In the following years, the further normalization of ventricular width is unimportant. The same is true following removal of an acoustic neurinoma; diminution in the size of the third ventricle is nearly finished within 6 months. The reduction in ventricular enlargement depends to a certain extent on the age of the patient. In children, complete normalization of the ventricular width was seen more often than in adults, where the third ventricle width was seldom reduced below 10.0 mm. In addition to age, duration of history and degree of hydrocephalus are of some significance in the decrease of ventricular dilatation. Fig. 12 summarizes 322 echoencephalographic follow-up studies in 87 patients. Fig. 13 shows how the diminution of the lateral ventricles is demonstrated by registering the position of the temporal horn echo.

A recurrence of ventricular dilatation is easy to detect by means of echoencephalography. An increasing distance of both reflections from the third ventricle walls after a transitory decline of the ventricular enlargement indicates a new disturbance of the cerebrospinal fluid flow. Fig. 14 shows four echoencephalograms in a patient with cysticercosis of the fourth ventricle who later developed granular ependymitis, causing a new dilatation of the third ventricle. Recurring tumors may also be diagnosed quickly in this way.

Discussion

The echoencephalographic diagnosis of hydrocephalus is based on the fact that the enlarged planes of the ventricular walls reflect the ultrasound to a high degree. From a temporal application point, the ultrasonic beam strikes the walls of the third ventricle and the temporal horn perpendicularly. The reflections originating from these structures are the decisive criteria for determining the degree of hydrocephalus. The lateral walls of the third ventricle produce a double echo in the middle of the echogram. The distance between these two reflections corresponds to the diameter of the third ventricle. The temporal horn echo arises from the external wall of the opposite lower horn. The position of this reflection facilitates the determination of the degree of ventricular enlargement.

After some experience, faulty interpretation of ultrasonograms is rare. The main source of error is when the reflection from the same wall of an enlarged third ventricle sounding from both sides is interpreted as

![Fig. 12. Decrease of ventricular dilatation after removal of tumor in the posterior fossa (average curve taken from 322 echoencephalographic follow-up studies).](image1)

![Fig. 13. Decrease of brain-mantle-index after restoration of cerebrospinal fluid flow.](image2)
the midline echo. This gives rise to a false midline echo shift measuring one-half the diameter of the third ventricle. In our series, only three patients gave unsatisfactory results concerning the midline echo. The width of the third ventricle determined by means of ultrasound was correct in all cases checked by pneumoencephalography. Echoencephalography makes possible not only the detection of midline shifts in the supratentorial space but also dilatation of the ventricular cavities. This is very important for early diagnosis of space-occupying lesions in the posterior fossa.

Postoperative echoencephalographic monitoring has provided fascinating insight into the behavior of the ventricular system after the surgical removal of a block. Hitherto the retrogression of hydrocephalus has only been recorded in the follow-up studies after ventriculocisternostomy and rare cases of cerebellar tumor. The earliest measurements, however, were not made until 1 to 3 months after restoration of the cerebrospinal fluid flow, and were necessarily crude. In most cases the interval of time was much longer. The technique we have described provides exact information concerning the day-to-day ventricular diminution. This is the first time such measurements have been recorded.

The advantages of echoencephalography in the diagnosis of space-occupying lesions in the posterior fossa are evident. It is especially valuable in outpatient care, since it allows demonstration of the ventricular width at any time within a few minutes. Even a beginner in echoencephalography can determine the midline echo in most cases; considerable experience in the use of ultrasound is, however, necessary for evaluating echoencephalograms in patients with dilated ventricles. We do not think it advisable for medical laboratory technicians to carry out this examination. This would increase the possibility of error and decrease the value of the method considerably. In the hands of well-experienced investigators, echoencephalography presents an essential enrichment of the diagnostic instrumentation. The demonstration of dilatation of the third ventricle in a patient with cerebellar signs, however, should lead to the next step, namely, ventriculography, vertebral angiography, and posterior fossa exploration.

Summary

We have reported the preoperative diagnostic reliability of echoencephalography in measuring the width of the third ventricle and the position of the lateral temporal horn echo, particularly in the presence of posterior fossa lesions that obstruct the flow of CSF. We have also described the use of echoencephalography in monitoring postoperative changes in the size of the third ventricle following removal of the obstruction. The combination of these factors makes this technique a valuable addition to the total preoperative study and postoperative management of obstructive hydrocephalus.
References


