The Localization of Brain Tumors by Ultrasound Techniques

A Clinical Review of 111 Cases

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The pathology and symptomaticity of brain tumors are now well understood. Diagnosis is sometimes assisted by air studies, arteriography and electroencephalography. Ultrasonic examination is a simple diagnostic technique, and has particular value in the advanced stages of brain tumor when arteriography or air studies are inadvisable.

The application of ultrasound for the purpose of diagnosis in the neurosurgical field has been reported since 1950.¹⁻⁷,²⁻³² Dussik,⁴ and Huerter and Bolt⁵ have tried to obtain a picture of the ventricles by a transmission method of ultrasound called hyperphonography. However, the picture of the ventricles was not as clear as a pneumoencephalogram. Recently the reflection method of ultrasound (echo) has been chiefly employed.

Since 1952, we have been utilizing the reflection method of ultrasound in the diagnosis of brain tumors. This paper summarizes our results.

Clinical Application of Ultrasonics

The pulsed ultrasonic wave which is radiated from a transducer travels through the brain tissue with a velocity of about 1500 m per sec. When the wave meets any object with a different acoustic nature, such as tumor tissue, it is reflected at the boundary of the object. These echoes are received by the transducer and changed into radio frequency electrical pulses of the order of microvolts, which are amplified and displayed on a cathode ray oscilloscope. As the various reflections are displayed vertically on a linear horizontal time base, the distance of the reflecting surfaces from the starting point of the transmitted pulse can be measured. By analysis of these ultrasonic echoes, correct diagnosis can be made.

To establish the accuracy of the reflection of the ultrasonic wave and the difference in acoustic impedance between brain tumor tissue and normal brain tissue, we conducted the following experiments with fresh tissue.

The apparatus used to measure velocity of sound in fresh tissue is shown in Fig. 1.* To make measurements the device was first clamped on the sample, then immersed in degassed water. Using a microscope on the films, the distance of the reflecting surface from the starting point of the transmitted pulse in each of the materials was compared. The density of the sample was measured by a solution of copper sulphate. The results of these experiments are shown in Table 1. It will be seen that the acoustic impedance of brain tumor tissue is greater than that of normal brain tissue. Thus it is theoretically possible that the border between brain tissue and tumor tissue will cause a reflection.

Ultrasonic Localization of Brain Tumor

Standard ultrasonic apparatus† was used with an adapted camera, and various types of medical transducer, manufactured commercially. In this series the types of transducer used were 1 and 2.25 megacycle, 10 mm. in diameter, for examination through the intact skull, and 5 and 10 megacycle, 3 or 10 mm. in diameter, for direct application to the brain. These were provided with barium titanate (1 and 2.25 megacycle) and piezoelectric quartz crystal (5 and 10 megacycle).

* The ultrasonic apparatus used was Model USF-5, manufactured by Japan Radio Co., Ltd., Tokyo, with an adapted camera.
† Aloka model SSD-2, manufactured by Japan Radio Co., Ltd., Tokyo.

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Methods of ultrasonic examination for the localization of brain tumors are as follows:

1. Examination through the skull. The skull has been said to be a great barrier to ultrasonic transmission because of its large attenuation. However, as already reported, we have succeeded in detecting echoes from brain tumors through the intact skull.

It is desirable to shave the hair in order to make a good contact; liquid paraffin is then applied on the surfaces of both the transducer and the scalp as a coupling medium. We usually hold the transducer by hand (Fig. 2). The suitable frequency of ultrasonic wave in this case is 2.25 megacycles per sec. with barium titanate crystals. Standard examination is performed through the temporal and frontal regions.

a) The Temporal Region. Examination through the temporal region is easier than elsewhere because the skull is thin. When the transducer is placed just in front of and over the ear, the echo originating from the third ventricle wall is detected as a midline pulsating echo. These pulsations are synchronous with the heart-beat. The so-called mid-

Fig. 1. The apparatus used to measure velocity of sound in fresh specimens.

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**TABLE 1**

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Velocity cm./sec.</th>
<th>Density g/cc.</th>
<th>Acoustic impedance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerebrum</td>
<td>1.44</td>
<td>1.056</td>
<td>0.151</td>
</tr>
<tr>
<td>Meningioma</td>
<td>1.04</td>
<td>1.050</td>
<td>0.172</td>
</tr>
<tr>
<td>Meningioma (fibroblastic type)</td>
<td>1.94</td>
<td>1.040</td>
<td>0.171</td>
</tr>
<tr>
<td>Meningioma (meningotheliomatous type)</td>
<td>1.96</td>
<td>1.048</td>
<td>0.173</td>
</tr>
<tr>
<td>Astrocytoma (grade II)</td>
<td>1.66</td>
<td>1.054</td>
<td>0.171</td>
</tr>
<tr>
<td>Retinoblastoma</td>
<td>1.50</td>
<td>1.040</td>
<td>0.167</td>
</tr>
<tr>
<td>Malignant meningioma</td>
<td>1.80</td>
<td>1.058</td>
<td>0.168</td>
</tr>
</tbody>
</table>

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Fig. 2. Apparatus in use during diagnosis of brain tumor at frontal region through the skull.