THE RELATIVE ACCURACY OF ELECTROENCEPHALOGRAPHY, AIR STUDIES AND ANGIOGRAPHY

IN A SERIES OF TWO HUNDRED MASS LESIONS*

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In the early part of this century the diagnosis of an intracranial mass lesion was made by clinical observations and roentgenographic studies. It was possible to localize a mass lesion in 40 to 60 per cent of patients by clinical studies. Roentgenograms, at first not too dependable, were of help in 15 per cent of cases. Ventriculography and pneumoencephalography were introduced in 1918 and 1919 by Dandy. Cerebral angiography was employed by Moniz in 1927, a procedure used infrequently in this country until the introduction of a percutaneous method of injection and a less toxic solution. Berger described electroencephalography in 1929.

More than two decades of experiences with these procedures have been recorded in the literature. Several observers²,³,⁴,⁵ have compared their diagnostic value. It is the purpose of this paper to compare the relative accuracy of encephalography, ventriculography, angiography and electroencephalography as they were used in the diagnosis of 200 verified, selected, but consecutive cases of mass intracranial lesions in a 4½-year period.

MATERIAL AND METHODS

The cases were selected on the basis of the following criteria: first, the type of lesion was space-occupying; second, the site of the lesion was established by surgery and/or autopsy; and third, the case was studied by several diagnostic methods. The histopathology was determined in all but 18 cases (Table 1).

The 224 electroencephalographic records used in this analysis were produced on an 8-channel, ink-writing, Model 3, Grass electroencephalograph. About 90 per cent of the records were recorded from leads placed according to the method of Gibbs. These records were essentially monopolar in origin, although short “runs” of bipolar leads were present in each. The other 10 per cent of the records were bipolar. The bipolar leads were placed according to a modification of the technique of Jasper. The electroencephalographic localization per se was made exclusively on the basis of the tracing. However, interpretation of the record was made in the light of the history.

The 90 pneumoencephalograms were performed by the removal of

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### TABLE I

#### I. MASSES OF THE CEREBRAL HEMISPHERES

(A) Neoplasms  
1. Glioma  
   - Glioblastoma 34  
   - Unclassified 14  
   - Astroblastoma 7  
   - Spongioblastoma 6  
   - Oligodendroglioma 5  
   - Astrocytoma 11  
2. Meningioma 12  
   - Benign 9  
   - Malignant 3  
3. Hemangioma 5  
4. Metastatic 3  

(B) Hematomas 45  
1. Subdural 37  
   - Acute 5  
   - Subacute 3  
   - Chronic 29  
2. Intraparenchymal 8  

(C) Abscesses 8

#### II. MASSES OF THE POSTERIOR FOSSA

(A) Neoplasms 30
1. Glioma 11
   - Unclassified 4  
   - Spongioblastoma 3  
   - Astroblastoma 1  
   - Astrocytoma 3  
2. Metastatic 6  
3. Medulloblastoma 5  
4. Meningioma 3  
5. Neurofibroma 3  
6. Hemangioma 1  
7. Neuroblastoma 1

#### III. MASSES OF THE MIDLINE BASE

(A) Neoplasms 19
1. Meningioma 9  
2. Pituitary tumor 5  
3. Chordoma 2  
4. Craniopharyngioma 2  
5. Neurofibroma 1

Cerebrospinal fluid and replacement with room air through the lumbar route. With the exception of cases of massive hydrocephalus, an attempt to replace the entire amount of fluid was made. This usually involved the exchange of 100 to 150 cc. The roentgenograms were made in both vertical and horizontal positions.

The 100 ventriculograms were performed by the replacement of ventricular fluid with room air through two burr openings centered at points 8 cm. above the external occipital protuberance and 3 cm. from the midline. All roentgen studies were made in the horizontal position.
The 58 carotid angiograms, with the exception of 3, were performed by the percutaneous method. Thorotrast was used in patients 55 years of age or more, or in those who were sensitive to diodrast.

RESULTS

Electroencephalography. Of the 224 preoperative electroencephalograms, which were recorded in 198 patients, 168 were abnormal. The diagnosis was aided by EEG in 101 cases, the graph indicating the site or cranial fossa of involvement. However, only 93 (47 per cent) of the lesions were localized to a discrete area. When posterior fossa and midline base lesions were excluded, an accuracy of 59 per cent was found (Table 2).

**TABLE 2**

<table>
<thead>
<tr>
<th>Electroencephalogram</th>
<th>Negative</th>
<th>Diffuse</th>
<th>Lateralizing</th>
<th>Fossa Focus</th>
<th>Exact Focus</th>
<th>False Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Masses of the cerebral hemispheres</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neoplasms</td>
<td>97</td>
<td>8</td>
<td>13</td>
<td>2</td>
<td>0</td>
<td>59</td>
</tr>
<tr>
<td>Abscesses</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Hematomas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intraparenchymal</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Subdural</td>
<td>36</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td><strong>Masses of the midline base</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neoplasms</td>
<td>18</td>
<td>12</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td><strong>Masses of the posterior fossa</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neoplasms</td>
<td>30</td>
<td>8</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

Accurate localization was made most often in cases of rapidly growing gliomas and the malignant meningiomas over the convexities. These were localized in 66 per cent of the cases.

The growth rate of the mass appeared to influence the frequency of appearance of discrete foci. The slower-growing gliomas of the hemispheres were localized in 62 per cent of the cases. The benign meningiomas involving the convexities and the hemangiomas of the hemispheres could be localized to an exact focus in 44 per cent and 40 per cent respectively.

Three of the 9 meningiomas that occurred at the midline base were localized by EEG because they produced pressure against the frontal lobes with EEG changes.

No exact focus was noted in any case of posterior fossa mass irrespective of the growth rate or predominant side of involvement.

Thirty-nine per cent of the subdural hematomas were localized to an area circumscribed well enough to be confined in a surgical bone flap.

All 8 intraparenchymal hematomas and all 9 of the abscesses were localized to an exact site.

False foci were found in 45 of the 198 cases. Fifty per cent of the masses
of the posterior fossa were falsely localized by the EEG. In the cases of posterior fossa lesions the appearance of false focal disturbances followed no consistent pattern. They appeared in both frontal and occipital leads more frequently than temporal leads. They occurred on either the same or on the opposite side of the tumor. Occasionally, the pattern was suggestive of a thalamic tumor.

Thirty-six per cent of the subdural hematomas were falsely localized by the EEG. Of the 37 hematomas 29 were chronic and existed with no severe associated cerebral damage. The presence of cerebral damage was not a factor causing false foci.

Eleven cases (all mass hemispheric lesions) were studied preoperatively by multiple EEGs. The following observations were noted: (1) Local extension of a discrete focus occurred in 8 of the cases. (2) Extension of a discrete focus across the midline to become a diffuse, random, or symmetrical abnormality occurred in 3 cases. (3) Intracranial hypertension was present in 9 cases with discrete foci which persisted in the presence of an increasing intracranial pressure. (4) In 6 cases there were focal abnormalities so early in the course of the disease that the mass was not evident by pneumoencephalographic or angiographic examination performed at that time.

Pneumoencephalography. Of the 90 pneumoencephalograms employed in the diagnosis of 82 cases, 46 were recorded as abnormal (Table 3). Thirty of the tumors were localized by this method, an accuracy of 36 per cent.

| TABLE 3

Pneumoencephalogram |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Masses of the cerebral hemispheres</td>
</tr>
<tr>
<td>Neoplasm 38</td>
</tr>
<tr>
<td>Abscess 3</td>
</tr>
<tr>
<td>Hematoma Intraparenchymal 2</td>
</tr>
<tr>
<td>Subdural 17</td>
</tr>
<tr>
<td>Masses of the midline base</td>
</tr>
<tr>
<td>Masses of the posterior fossa</td>
</tr>
</tbody>
</table>

Accurate localization of tumors was made most often in cases of rapidly growing gliomas of the cerebral hemispheres. Forty per cent of these were localizable.

Eleven of the 17 subdural hematomas were lateralized. However, only 2 were localized to an exact site. Two intraparenchymal hematomas and 3 abscesses were localized in all cases.

None of the posterior fossa masses could be localized to an exact site and only 1 was localized to this fossa.
TABLE 4

Ventriculogram

<table>
<thead>
<tr>
<th></th>
<th>Negative</th>
<th>Lateralizing</th>
<th>Fossa Focus</th>
<th>Exact Focus</th>
<th>Diagnostic Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masses of the cerebral hemispheres</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neoplasms</td>
<td>55</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>47</td>
</tr>
<tr>
<td>Abscesses</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Hematomas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intraparenchymal</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Subdural</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Masses of the midline base</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neoplasms</td>
<td>3</td>
<td></td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Masses of the posterior fossa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neoplasms</td>
<td>29</td>
<td></td>
<td>2</td>
<td>0</td>
<td>24</td>
</tr>
</tbody>
</table>

Eight of the 13 tumors that occurred at the midline base were localized by this method. In most cases this was because of defects in the pattern of the basal cisterns rather than the ventricles.

There were 23 diagnostic failures because of insufficient aeration of the ventricular and subarachnoid spaces. Seven of the 9 pneumoencephalograms performed in cases of posterior fossa tumors, and 13 of the 38 performed in cases of hemispheric tumors were failures. In 11 of the cases successful ventriculography was subsequently performed.

Ventriculography. Of the 100 ventriculograms performed on 96 patients, 4 were diagnostic failures because of insufficient ventricular filling. These were successfully repeated. In 88 of the studies the findings were abnormal and in 86 they were diagnostic. This is an accuracy of 90 per cent.

Of the 29 lesions in the posterior fossa, only 3 were localized to an exact site. However, 24 of these studies localized the lesion to the fossa.

In only 1 of the 3 ventriculograms performed on patients with midline base tumors was the site of the tumor revealed.

TABLE 5

Angiogram

<table>
<thead>
<tr>
<th></th>
<th>Negative</th>
<th>Exact Focus</th>
<th>False Focus</th>
<th>Diagnostic Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masses of the cerebral hemisphere</td>
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<td></td>
</tr>
<tr>
<td>Neoplasms</td>
<td>37</td>
<td>14</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Abscesses</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Hematomas</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intraparenchymal</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Subdursals</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Masses of the midline base</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neoplasms</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>
As will be noted in Table 4 it was possible to localize accurately 75 per cent of the hematomas and abscesses by this method.

Angiography. Fifty-seven carotid angiograms were performed on 57 patients. Of the 57 masses 31 were localized to an exact site. Among the neoplasms that occurred in the hemispheres, 57 per cent were accurately localized by this method. These masses occurred in the anterior two-thirds of the hemispheres.

Half of the subdural hematomas (6 cases) and midline base lesions (8 cases) were localized. The intraparenchymal hematomas and abscesses were also localized with a high degree of accuracy (Table 5).

DISCUSSION

No single method is adequate in the localization of all types of intracranial mass lesions. The method of choice will depend not only on the physical status of the patient, but also upon the diagnostician's clinical concept of the site of the lesion.

Electroencephalography may be used in all patients capable of cooperating, but it can be considered only as an adjunct to other diagnostic methods. It must be remembered that projected EEG abnormalities may be falsely interpreted as focal abnormalities and focal abnormalities tend to become generalized with progression of the disease.

Local extension of a discrete focus is probably caused by local growth of the tumor rather than by increased intracranial pressure. Nine of the 11 patients who were studied by multiple EEGs had persistent foci in the presence of a rise in intracranial pressure. A focal abnormality became a general abnormality in 3 cases. This extension of the abnormality may be the result of invasion of midline structures or may be caused by artefact from monopolar lead placement which utilizes ear leads in common.

Electroencephalographic examination of the patient early in the course of his disease is desirable. Not only is it possible to obtain more discrete foci, but in 6 of the 12 cases, an EEG focus was noted when pneumoencephalographic and angiographic findings were negative.

Encephalography is useful in the diagnosis of lesions above the tentorium cerebelli. Masses that occur in the basal cisterns, an area that is not visualized by ventriculography, may be delineated by pneumoencephalography.

Failure of filling of the ventricular system is presumptive evidence of an intracranial mass lesion. The presence of increased intracranial pressure as a cause for these failures was first suggested experimentally by Jüngling and clinically by Bohn, who reported tumors and anesthesia as causes for the rise in intracranial pressure. In our group, although all had mass lesions, none had papilledema at the time of pneumoencephalography and only 2 had general anesthesia.

Ventriculography is the most nearly accurate method available. It is
the method of choice in cases of posterior fossa lesions or when intracranial hypertension is present.

Carotid angiography is most useful in the diagnosis of lesions occurring in the anterior two-thirds of the cerebral hemispheres and those that occur at the midline base (optic and supra-optic region). It is the method of choice in the desperately sick patient with a mass lesion at these sites.

SUMMARY

The relative value of electroencephalography, pneumoencephalography, ventriculography and angiography in the diagnosis of 200 cases of mass lesions is discussed.

Electroencephalography is useful only as an aid to other diagnostic methods.

Pneumoencephalography is valuable in the localization of hemispheric mass lesions and is the procedure of choice with tumors at the midline base.

Ventriculography is the most useful method in the localization of any intracranial mass lesion, having a general accuracy of 90 per cent. It is the only method, with the exception of vertebral angiography, that is helpful in the diagnosis of posterior fossa masses.

Masses of the anterior two-thirds of the hemispheres and about 50 per cent of those that occur at the midline base may be localized by carotid angiography.

REFERENCES