Detection of 247 midline and posterior fossa tumors by combined scintigraphic and digital gammaencephalography

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The authors report their experience using digital and scintigraphic techniques simultaneously, with the application of two isotopes (mercury 197/203 and technetium-99m) of different tissue uptake. Basal supratentorial midline cerebral tumors (88 cases) and posterior fossa tumors (159 cases) could be diagnosed in over 90% of cases. This safe isotope investigation of the intracranial structures offers diagnostic help as a screening method before angiography and pneumoencephalography.

KEY WORDS: brain tumor, midline, basal tumor, posterior fossa tumor, gammaencephalography, digital and scintigraphic measurement, Hg 197/203, 99m-technetium

BASAL midline brain tumors (sellar region, hypothalamus, thalamus, midbrain, and pineal region) are as difficult to demonstrate directly with radioactive isotopes as are posterior fossa and brain stem tumors. Recently some authors, using refined measurement techniques, have published results of an accuracy comparable to those for tumors of the cerebral hemispheres. However, the number of cases in these reports have been small, and the techniques vary with each investigator.

We therefore felt that a demonstration of the results from a large collection of cases using our technique of measurement would be relevant.

Materials and Methods

From 1965 to 1972, 6000 gammaencephalographic examinations were carried out. From this series, 88 patients were found to have supratentorial midline tumors and 159 to have tumors of the posterior fossa. A number of examinations suggested the presence of a lesion but were not included in this survey. In all of the patients the lesion was confirmed by operation, biopsy, or autopsy. Most of the patients had neurological evidence referable to the site of the lesion at the time of gammaencephalography so that it was a search test for the tumor.

A combination of digital and scintigraphic measurement techniques was used. For the orthogonal multiple field digital measurements, mercury 197/203 neohydrin (Hg 197/203) was combined simultaneously with technetium 99m-pertechnetate (Tc99m); and for the color-scintigraphy,
Combined scintigraphic and digital gammaencephalography

Indium 113 m-EDTA (In$^{113}$) was used. The intravenous dose was 10 μCi/kg for Hg$^{197}$/Hg$^{70}$, 70-104 μCi/kg for Tc$^{99m}$, and 100 μCi/kg for In$^{113}$.

Digital measurements were obtained over the dorsal and two lateral aspects of the skull from adjacently arranged measuring points 2 x 17 and 1 x 10 respectively. Recordings were made at 2½ hrs and again at 24 hrs after the isotope injection. The interpretation of digital values was determined by a computer. The color-scintigraphic determinations were obtained over the anteroposterior, posteroanterior, and lateral scans. These were made mostly from 3½ to 4½ hrs after the intravenous injection of Tc$^{99m}$. We consider these time periods of around 4 hours particularly necessary for aplastic, fibrous, avascular tumors, because the isotope concentration gradient in the tumor is greatest during this period of time. The In$^{113}$ was measured 15 to 45 minutes after intravenous injection as well as by the usual 3 in. crystal rectilinear scanner.* In no patient did complications occur.

Results

Midline Tumors

In Table 1 the accuracy of our interpretation of the gammaencephalogram regarding tumor presence and type is compared with the actual operative and histological findings. Although there is no histological confirmation for three of 88 tumors, on the basis of neurological symptoms and neuroradiological findings, there is no doubt that these were space-occupying lesions.

In the glioma series (32 cases) all but four tumors were clearly localized. Eight tumors histologically diagnosed as astrocytomas were also clearly localized; five of these were in the diencephalon, two in the corpus callosum, and one in the basal ganglia.

Of the 41 tumors in the sellar region, 29 were hypophyseal adenomas and 12 craniopharyngiomas. A good focal uptake was also seen in cases that were later confirmed as cystic craniopharyngiomas. This is explained by the increased isotope uptake in the tumor capsule and adjacent compressed brain substance, rather than by uptake in the cystic fluid. Eighteen of 29 hypophyseal adenomas were correctly recognized with the gammaencephalogram. However, the largest number of failures were in this group; one-fifth of the hypophyseal adenomas were not recognized. This is not surprising, since these are small tumors and must be of a size greater than 1.5 cm to become evident on the scan. In the anterior fossa, all five olfactory meningiomas were exactly localized and correctly diagnosed.

In the cases of one thalamic and two diencephalic tumors, a definitive tumor diagnosis could not be made on the gammaencephalogram. A space-occupying mass was evident from the clinical course and was confirmed by the pneumoencephalogram (Fig. 1). One patient who was misdiagnosed as having arachnoiditis of the optic chiasm showed no clear evidence of tumor on the gammaencephalogram, pneumoencephalogram, or angiogram; at autopsy a Burkitt tumor of the hypothalamus was demonstrated.

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*Picker Magnascanner 500 manufactured by Picker Röntgen, 4992 Espelkamp, West Germany.

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<table>
<thead>
<tr>
<th>Midline Tumor</th>
<th>No. of Cases</th>
<th>Localization*</th>
</tr>
</thead>
<tbody>
<tr>
<td>pituitary adenoma</td>
<td>29</td>
<td>+ 18 (+) 7</td>
</tr>
<tr>
<td>craniopharyngioma</td>
<td>12</td>
<td>10 2 -</td>
</tr>
<tr>
<td>astrocytoma</td>
<td>8</td>
<td>8 -</td>
</tr>
<tr>
<td>spongiosblastoma</td>
<td>11</td>
<td>11 3 4</td>
</tr>
<tr>
<td>oligodendroglioma</td>
<td>5</td>
<td>3 4 1 -</td>
</tr>
<tr>
<td>glioblastoma</td>
<td>1</td>
<td>3 -</td>
</tr>
<tr>
<td>ependymoma</td>
<td>1</td>
<td>3 -</td>
</tr>
<tr>
<td>plexus papilloma</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>medulloblastoma</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>meningioma</td>
<td>8</td>
<td>8 -</td>
</tr>
<tr>
<td>metastatic tumor</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>unclassified tumor</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Burkitt tumor</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>88</strong></td>
<td><strong>68 12 8</strong></td>
</tr>
</tbody>
</table>

* + = clear diagnostically valuable focal uptake in a site corresponding to the clinical findings. (+) = diffuse weakly defined questionable uptake in an area suggested by unequivocal clinical findings. - = absence of any focal gamma encephalographic uptake in spite of focal clinical findings.
Fro. 1. Te99m colorscintigram of a ½-year-old child with signs of advanced increased intracranial pressure. Immediate ventricular drainage was accomplished through the open fontanel. A colorscintigram was the primary diagnostic procedure. Left: Lateral view showing a 3.5 × 3.5 cm well-localized focal uptake in the suprasellar region, suggesting a mass obstructing the foramina of Monro and causing hydrocephalus. The dilated lateral ventricles are indicated by the wide area of diminished isotope uptake. Right: Anteroposterior view showing the uptake as a dome-shaped midline focus. Subsequent pneumoencephalography confirmed this evidence of tumor.

**Tumors of the Posterior Fossa**

Table 2 summarizes the results of gammaencephalography in 159 cases of posterior fossa tumor. In this group 67% could be clearly diagnosed; probable findings, confirmed later by operation or neuroradiological methods, were made in 29%.

The isotope uptake of the tumor tissue differed with the tumor type. Spongioblastomas (41 cases) were correctly demonstrated in 70%, medulloblastomas (20 cases) in 69%, and ependymomas (10 cases) in 75%. Of 31 cases of acoustic neurinomas, 61% were correctly diagnosed (Fig. 2); the apparent focal uptake by acoustic neurinomas was often more marked than could be justified by the size of the tumor found later at operation. Evidently radioisotope tissue uptake is more intense in the capsule of the neurinoma and in the surrounding brain tissue than in the tumor itself.

Metastases in the posterior fossa were all detectable; five of 12 cases were clearly demonstrated and seven cases showed probable findings later confirmed by operation and autopsy. Vascular and infectious diseases of the posterior fossa could be diagnosed distinctly in only a small percentage. These were not included in the survey. Other lesions occurred in so few cases that no statement can be made.

**TABLE 2**

<table>
<thead>
<tr>
<th>Posterior Fossa Tumor</th>
<th>No. of Cases</th>
<th>Localization*</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>spongioblastoma</td>
<td>43</td>
<td>30</td>
<td>11</td>
</tr>
<tr>
<td>medulloblastoma</td>
<td>26</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>ependymoma</td>
<td>12</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>glioma</td>
<td>6</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>acoustic neuroma</td>
<td>36</td>
<td>23</td>
<td>10</td>
</tr>
<tr>
<td>meningioma</td>
<td>9</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Lindau tumor</td>
<td>6</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>metastatic tumor</td>
<td>15</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>dysplastic cysts</td>
<td>6</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td>159</td>
<td>106</td>
<td>46</td>
</tr>
</tbody>
</table>

* = clear diagnostically valuable focal uptake in a site corresponding to the clinical findings. (+) = diffuse weakly defined questionable uptake in an area suggested by unequivocal clinical findings. — = absence of any focal gamma encephalographic uptake in spite of focal clinical findings.
Combined scintigraphic and digital gammaencephalography

Fig. 2. Tc99m colorsctigram of a 64-year-old woman with evidence of recurrent acoustic neurinoma 3 years after operation. Left: Lateral view indicating a dense dome-shaped tumor in the area of the cerebellopontine angle. Right: Posteroanterior view showing that the focus has spread laterally from the midline. The sharp distinction between the tumor and its surroundings is evident. Operation verified both localization and size of the tumor.

Discussion

The demonstration of midline basal and posterior fossa tumors is admittedly difficult because of the muscle insertions overlying the base of the skull and the rich vascular supply, especially that of the venous sinus, overlying the cerebellum. Thus our results show a large number of suspected cases which were later confirmed by operation or other investigations. We were able to make a positive diagnosis in 78% of the cases of basal supratentorial midline tumors and a probable diagnosis in 13%. However, with the posterior fossa tumors, the percentage of positive findings was reduced to 67%, whereas the probable findings were 29%. Over 90% of these probable findings were later confirmed at operation. In no case did a positive scintigraphic finding correlate with a negative digital finding. In all those cases confirmed pathologically, the digital measurements showed pathologically high impulse rates of corresponding fields. However, the scintigam showed a definite pathological pattern in only 75% of these cases. For the rest of the cases the use of two different isotopes with different tissue uptake was valuable in making a positive diagnosis.

While the intracellular Hg-incorporation depends on and is limited by the number of free sulfhydryl radicals, the uptake of Tc is similar to the uptake of bismuth, and is determined exclusively by diffusion and a high intracellular complex stability in the tumor cell. The reliable demonstration of the tumor limits as presented on the scan is valuable in our use of interstitial Curie therapy. The borders of the focal uptake in the scan coincide almost completely with the histological findings in the tumor as proved by stereotaxic biopsies.

A comparison of our results with those of other authors is problematic because both the radioisotopes and the techniques of measurement differed. Mercury 197 and 203 as well as iodine 131 have been used for digital and scintigraphic techniques. The accuracy of the findings has been between 40% and 60%. With the use of Tc99m in recent years, the results have been better and more comparable to ours. Koos, et al., correctly demonstrated 16 of 18 midline tumors in children and 18 of 20 tumors of the posterior fossa using Tc99m scan. Hirschbiegel and Böcken reported 54 cases of tumors of the posterior fossa; 76% of these were recognized positively and 13% were diagnosed as probable. Moody, et al., reported a 78% diagnostic accuracy in 37 tumors of the posterior fossa.

Naturally, diagnostic accuracy differs with tumor type. Meningiomas can nearly always be demonstrated because of their

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very strong uptake of radioisotope. Slightly vascularized tumors such as hypophyseal adenomas and acoustic neurinomas are diagnosed less often. Astrocytomas are recognized with the same rate of accuracy as that for other tumors of the glioma series. Moreno and DeLand claim a diagnostic accuracy of 80%.

The topographical component of any diagnostic measurement is of special importance for the neurosurgeon; we believe that at present a rectilinear scan in correct scale offers the best results. Our serial angioscintigrams with the digital autofluoroscope of Bender* added only supplementary information regarding classification of the tumor.24

These diagnostic techniques have limited value and should not be the sole or routine methods used; generally they do not take the place of angiography.7

Acknowledgment

All histological results were reviewed and confirmed by Prof. H. Noetzel from the Department of Neuropathology of the Institute of Pathology of the University of Freiburg. We are grateful to him for allowing the use of these results.

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