Brain Scanning with $^{99m}$Technetium

COURTLAND H. DAVIS, JR., M.D., EBEN ALEXANDER, JR., M.D.,
RICHARD L. WITCOFSKI, M.S., AND C. DOUGLAS MAYNARD, M.D.

Department of Surgery, Section on Neurosurgery, and the Department of Radiology, the Medical Center of the
Bowman Gray School of Medicine and the North Carolina Baptist Hospital, Winston-Salem, North Carolina

$^{99m}$Technetium in the form of pertechnetate has become a valuable diagnostic tool in radioisotopic scanning of the brain. Introduced by Harper and his associates\(^2\) in 1963, this agent is now being used in a number of medical centers.\(^1,6,7,9,10,15\) This report describes its use in more than 700 brain scans performed at the North Carolina Baptist Hospital from June, 1964, to June, 1965.

Method

The $^{99m}$Tc is obtained from a $^{99}$Mo-$^{99m}$Tc generator.* The parent agent, $^{99}$Mo, decays with a half life of 67 hours leaving a short-lived product, $^{99m}$Tc (half life of 6 hours). The metastable $^{99m}$Tc decays to $^{99}$Tc with a gamma emission of approximately 140 Kev.

The short-lived $^{99m}$Tc is obtained from the generator by pouring 15 milliliters of normal saline into the top of the generator and collecting the product solution as it drips from the bottom. The material is then calibrated with an ionization chamber. The yield of $^{99m}$Tc has been equal to approximately 65 per cent of the initial activity corrected for decay to the day in question. Approximately half the morning yield can be obtained in about 5 to 6 hours with little effect on the yield the following day.

The $^{99m}$Tc may be administered either orally after the patient has fasted for at least 6 hours, or intravenously after the material has been autoclaved. Our regular dose for brain scanning is 10 millicuries.

Scanning is begun after 10 minutes. With a Picker Magnascanner (3 X 2 in. crystal) and a 19-hole collimator, we routinely obtain 7,000 to 10,000 counts per minute. The following settings are used with this count-range: window of 130 to 160 Kev., scanning speed of 60 to 120 cm./min., and a line-spacing of 0.3 cm. with a small photodot. We obtain both laterals and either an anterior or a posterior view, depending on the findings from the lateral views or the clinical impression. If a lesion of the posterior fossa is suspected, an angled view, such as a reversed Towne, is helpful. At present about 1 to 1½ hours' scanning time is required.

In the negative brain scan, spaces containing blood, such as the superior sagittal and the transverse sinuses, are sharply defined, as are the muscles and the mucous membranes (Fig. 1). The posterior fossa is visualized on the lateral (Fig. 2) and posterior projections (Fig. 3) by reference to the transverse sinus. A localized area is interpreted as abnormal when it shows an increased

Received for publication November 29, 1965.

* Supplied by the Brookhaven National Laboratory, Upton, New York, or by Iso/Serv, Inc., 131 Portland Street, Cambridge 39, Massachusetts.
TABLE 1

Positive scans: 41 tumors found

<table>
<thead>
<tr>
<th>Supratentorial (35)</th>
<th>Infratentorial (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glioblastomas multiforme (12) (Fig. 4)</td>
<td>Astrocytomas (5)</td>
</tr>
<tr>
<td>Metastatic tumors (8) (Fig. 5)</td>
<td>Medulloblastoma (1)</td>
</tr>
<tr>
<td>Astrocytomas (6)</td>
<td>Medulloblastoma (1) (Fig. 8)</td>
</tr>
<tr>
<td>Meningiomas (5) (Fig. 6)</td>
<td>Acoustic nerve tumor (1)</td>
</tr>
<tr>
<td>Oligodendrogliomas (2)</td>
<td>Metastatic tumor (1)</td>
</tr>
<tr>
<td>Papilloma of the choroid plexus (1)</td>
<td></td>
</tr>
<tr>
<td>Ependymoma (1) (Fig. 7)</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 2

Negative (erroneous) scans: 10 tumors missed

<table>
<thead>
<tr>
<th>Supratentorial (6)</th>
<th>Infratentorial (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astrocytomas of the temporal lobe, benign (5)</td>
<td>Medulloblastoma (1)</td>
</tr>
<tr>
<td>Metastatic tumor from the breast, small and deep in parietal lobe (1)</td>
<td>Hemangioblastoma (1)</td>
</tr>
<tr>
<td>Neurinoma of 11th nerve (1)</td>
<td></td>
</tr>
<tr>
<td>Metastatic tumor (no posterior scan obtained) (1)</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3. Negative angled posterior brain scan with $^{99m}$Tc.

Fig. 4. Positive brain scan of a patient with a glioblastoma multiforme.

Fig. 5. Positive brain scan of a patient with a metastatic tumor.
count-rate in 3 or more successive scanning lines and in at least 2 projections at right angles to one another.

**Results**

During the year of this study, 51 patients who had scanning procedures had a tumor of the brain which was verified histologically. In 41 of these patients the scans were positive, while in 10 the scans were negative, an accuracy of about 80 per cent.

In the 41 patients with positive scans, 41 tumors were found (Table 1). Ten tumors were missed in the false negative scans (Table 2).

As could be expected, 4 small tumors of the pituitary gland and 1 epithelioma of the floor of the middle fossa could not be visualized unequivocally. In addition, 2 patients had negative scans with tumors of the pineal region which were diagnosed by ventriculography but not verified histologically.

In patients with nonneoplastic disease, positive scans have been obtained with subdural hematoma, arteriovenous malformation (Figs. 9 and 10), cerebral infarction, contusion of the brain or scalp, or both, subarachnoid hemorrhage, leukemic infiltrates, focal encephalitis, polyarteritis, acute multiple sclerosis, and localized pneumococcal cerebritis. It was interesting to find that 2 patients with fresh lesions from thalamotomy for parkinsonism showed negative scans except for peripheral changes in the region of the surgical openings.

**Discussion**

At its present stage of development, radioisotopic scanning of the brain is 60 to 90 per cent accurate in the detection of intracranial tumors. 6,10 There has been no morbidity or mortality from the test. Combined with arteriography, an over-all accuracy of 94 per
False-negative or equivocal scans have often been associated with slowly growing gliomas of the cerebrum or pons, cysts, pituitary lesions confined within the sella turcica, and lesions in the posterior fossa. Positive scans are sometimes obtained from such nonneoplastic lesions of the brain as infarction, intracranial hematoma, aneurysm, arteriovenous malformation, contusion of the brain or scalp, or both, subdural hematoma and abscess, and localized inflammatory disease, including various granulomas and pyogenic abscess. Very few brain scans are falsely positive. Improvements in accurate detection and localization will depend on the use of tagged agents having a greater biologic affinity for the abnormal tissue and with better physical characteristics of emitted radioactivity, as well as more sensitive detectors with better recording characteristics.

Improved detecting devices are being developed. Biologic characteristics of a number of labelled substances are known and further studies are continuing at a necessarily slow pace. Quantitative physical characteristics are more easily evaluated.

In this latter category, $^{99m}$Tc pertechnetate is clearly superior to the substances previously used for brain scanning. It has essentially monoenergetic gamma emissions of 140 Kev., absence of beta emission, and a short physical half life of 6 hours. These characteristics permit the administration of the relatively large dose of 10 mc. with a
significant reduction in the length of procedure; yet the radiation dose is kept below the level reached with other agents. The tumor-to-brain concentration (mouse ependymoma) is similar to that with $^{203}$Hg chlormerodrin (22:1).

Conclusions

In our experience, $^{99m}$Tc has proved to be a valuable screening agent.

The advantages of this material include the ease of administration, the availability of both oral and intravenous therapy, the high count-rate and potential for high scanning speed, the relatively low radiation dosage, the optimum level of energy of 140 Kev., the decrease in total testing time, and the comparatively low cost.

Disadvantages include the need to “milk” the generator at least once daily (a 20-minute process) and the rapid decay of $^{99m}$Tc which prevents shelf storage. A few patients (3 of our 142) failed to absorb an adequate amount of orally administered $^{99m}$Tc.

Summary

The use of $^{99m}$Tc (in the pertechnetate form) makes possible rapid brain scans of superior quality at reasonable cost and low radiation dosage. In a series of 51 histologically verified brain tumors, there was an accuracy of 80 per cent; the false-negative scans occurred in the same type of case which had led to false-negative scans with other agents. We have commented briefly on positive scans in nonneoplastic brain lesions. We have described our method including a variation in positioning which permits better scanning for lesions in the posterior fossa.

References