Evaluation of postcraniotomy patients by radionuclide scan

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Twenty-eight patients with cerebral tumors were evaluated after craniotomy with combined radionuclide techniques in order to assess presence or absence of tumor recurrence. The combination of a positive pertechnetate or Tc-phosphate scan with a positive gallium scan strongly indicates the presence of recurrent or residual tumor. Infection may also cause uptake but was easily distinguished by the distribution. Negative gallium scans with positive technetium scans were indicative of non-recurrence in this series.

**KEYWORDS**
- craniotomy
- brain neoplasms
- radioisotope scanning
- multiple radionuclides
- radio gallium

**GALLIUM (Ga)** scanning of the brain has been employed recently in the detection of brain tumors and in the differential diagnosis of cerebral lesions.1,3,5 The most likely mechanism for gallium accumulation in brain lesions is a combination of blood-brain barrier breakdown and of active retention in highly cellular tissue.5 Postcraniotomy patients may have positive technetium brain scans at the surgical site for long periods after the operation, making the detection of tumor recurrence notoriously difficult.6 The purpose of this report is to evaluate a method of assessing postcraniotomy patients using 67Ga scanning as well as conventional brain and bone scanning.

**Methods and Materials**

Twenty-eight postcraniotomy patients were evaluated with both 99mTc as pertechnetate and 67Ga-citrate. Fifteen patients also had 99mTc-polypophosphate or -diphosphonate (hereafter summarized by the term Tc-phosphate) scans of the head. The time between operation and scans varied from 4 weeks to 4 years. The studies were done using dual-headed 5-in. crystal rectilinear scanners or Anger cameras. If possible, summation of the 184 keV and the 296 keV photopeaks were used with gallium. If the double peak analyzer equipment was not available, the 184 keV peak only was used. Gallium scans were done 2 to 7 days after intravenous injection of 3 mCi 67Ga-citrate. For each patient, care was taken to perform comparison scans on the same image system. NaTcO4 and Tc-phosphate scans were carried out 4 hours after injection.

The original diagnosis was established in all cases by surgery. Recurrence was proven by surgery, autopsy, or angiography. Lack of recurrence was determined by angiography,
as part of an established protocol. The scans were initially interpreted independent of knowledge of recurrence.

**Results**

**Nonrecurrence of Tumor**

A comparison of sodium pertechnetate (NaTcO₄), Tc-phosphate, and Ga scans in a single patient is shown in Fig. 1. This patient had had a craniotomy for metastatic choriocarcinoma 3 years previously and had been treated since with chemotherapy and radiotherapy, without any evidence of recurrence clinically or by chorionic gonadotropin titers. Note the increased activity along the left calvarium on the posterior view with ⁹⁹mTc-pertechnetate (left) and crescentic increase in activity on the left with ⁹⁹mTc-diphosphonate (middle). This pattern was noted in 11 cases thought to have no tumor recurrence at the time of the scan.

**Tumor Recurrence**

Figure 2 shows scans demonstrating tumor recurrence in a patient with a Grade II astrocytoma treated with resection and radiotherapy. In this case, tumor recurrence was confirmed at surgery. The increased calvarial activity on the left can be seen on the posterior projection, and an increase in the temporal parietal region is seen on both the posterior and lateral views (upper). The gallium scans (lower) fail to show the calvarial increase, but clearly demonstrate the extensive deep lesion.

The effects of craniotomy on a brain scan in a patient with a glioblastoma are seen in Fig. 3. Note the increased calvarial uptake on the right in the pertechnetate scans done 8 months after surgery. Tumor recurrence was proven by angiography. The gallium scan clearly shows the deep uptake away from the calvarium.
Postcraniotomy evaluation by radionuclide scan

Effect of Infection on Scans

Figure 4 demonstrates a case of osteomyelitis of the skull along the bone flap confirmed by biopsy. Surgery was done 8 months prior to the scan. Note the intense gallium accumulation along the left posterior calvarial surface while the pertechnetate and polyphosphate studies are both considered equivocal.

Summary of Results

The results of different scans in our series are summarized in Table 1. Table 2 shows the incidence of recurrence according to histology. The nonrecurrent group is also categorized by the intervals between surgery and scan.

With $^{67}$Ga as with $^{99m}$Tc, a postoperative baseline scan performed approximately 2 to 3
Fig. 3. Pre- and postoperative scans in a patient with glioblastoma. **Left:** Precraniotomy pertechnetate studies. **Center:** Postcraniotomy pertechnetate scans. **Right:** Postcraniotomy gallium scans. **Upper:** Posterior view. **Lower:** Right lateral view. Note both the superficial and deep concentrations on the postoperative pertechnetate scan, while the gallium shows only the deep lesion.

Fig. 4. Postcraniotomy osteomyelitis confirmed at biopsy. **Left:** Pertechnetate scans. **Center:** Polyphosphate scans. **Right:** Gallium scans. **Upper:** Posterior view. **Lower:** Left lateral projection. Note the extensive superficial uptake with gallium, while the pertechnetate and phosphate scans are equivocal.
TABLE 1  
Nuclide uptake in tumor patients after craniotomy  

<table>
<thead>
<tr>
<th>Type of Scan</th>
<th>$^{99m}$Tc-pertechnetate</th>
<th>$^{99m}$Tc-polyphosphate</th>
<th>$^{67}$Ga-citrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>tumor recurrence*</td>
<td>16</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>no recurrence†</td>
<td>11</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>osteomyelitis</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

* Demonstrated by surgery, autopsy, or angiography.  † Demonstrated by angiography, surgery, or stable clinical course.

months after surgery is useful in evaluation of later progression versus regression of abnormalities, another useful indicator of tumor recurrence. The $^{99m}$Tc-phosphate scan is suggested only in those cases where suspected tumor involvement of the calvarium is not apparent with either pertechnetate or gallium.

Discussion

In the case illustrated in Fig. 1, the pertechnetate and phosphate studies are strongly positive in the craniotomy area in spite of the scans being performed 3 years postoperatively. The gallium scan is normal. This patient has had no recurrence of her choriocarcinoma. The study is representative of others in which the tumor had not recurred, as confirmed by angiography, repeated surgery, and/or the clinical course. All patients in this group were asymptomatic and were not receiving chemotherapy or radiotherapy at the time of the scans. The postoperative follow-up time varied from 6 months to 4 years.

Figures 2 and 3 represent cases of tumor recurrence. The pattern of a positive pertechnetate and/or phosphate study with an abnormal gallium study was noted in all cases where recurrent tumor was shown to be present by angiography or repeated surgery. In the patient with osteomyelitis (Fig. 4), the distribution pattern of the gallium differed markedly from those with tumor recurrence, in that tumor recurrence was generally focal and deep while the osteomyelitis was superficial and diffuse. It is conceivable, however, that localized osteomyelitis may simulate recurrent tumor on combination scans.

A negative postoperative gallium scan in a patient with possible recurrent tumor is, according to this series, good evidence of tumor absence. However, it is not conclusive, since negative gallium brain scans have been seen in proven tumors, although rarely, and it is well accepted that a tumor must have a minimum size of 1.5 to 2 cm to be seen with any radionuclide. In addition, patients under or shortly after chemotherapy or radiotherapy are less likely to have significant uptake even if tumor is present.

References


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