A Comparison of 1- and 2-Hr Delayed Brain Scans in Patients Undergoing Chemotherapy for Primary Brain Tumors

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Fifty-five patients receiving various forms of chemotherapy for primary brain tumors had brain scans performed at 1 hr and again at 2 hr following injection of the radionuclide. The images were compared for changes in lesion size, lesion intensity, and surgical flap intensity. Sixteen percent (9) of the patients showed a definite increase in size of the lesions and 29% (16) a definite increase in intensity from 1-hr to the 2-hr scan. Fifty-one percent (28) of the patients showed fading in surgical flap intensity. One case of primary neoplasm, one case of meningeal spread of tumor, and one case of subdural hematoma were detected only on the 2-hr view. In addition, changes in the so-called doughnut sign were observed. These findings demonstrate a need for strict adherence to a specified time between injection and imaging in studying brain lesions receiving chemotherapy, and emphasize the superiority of the 2-hr scan for evaluation of these patients.

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A recent study at our institution revealed that the brain scan is the best single laboratory test for early detection of reduced tumor regrowth in patients receiving chemotherapy for brain tumors (*1*). In an effort to improve further the value of the brain scan in evaluating these patients, we have recently increased the interval between injection of radionuclide (Tc-99m DTPA) and imaging from 1 to 2 hr. The purpose of this study was to determine any significant changes in the detectability or appearance of lesions in the studies delayed 1 hr compared with those delayed 2 hr.

MATERIALS AND METHODS

Fifty-five patients receiving various forms of chemotherapy for primary brain tumors underwent brain scanning at 1 hr and again at 2 hr after intravenous injection of 20 mCi technetium-99m DTPA. The scanning was done at the ends of their courses of chemotherapy, which varied from 4 to 8 weeks, and before re-evaluation. The histologic diagnoses of these tumors are listed in Table 1. Five views, consisting of anterior, posterior, right and left lateral, and vertex, were obtained at 1 hr; 400,000 counts were collected per view. Views that best delineated the lesion were repeated at 2 hr, using either 250,000 counts per view or (if counting rate was less than 50,000/min) 5 min per view. If no lesion was detectable on the 1-hr image, a 2-hr view was selected based on the location of the original tumor. The images obtained at 1 and 2 hr were compared for changes in lesion size, lesion intensity (as compared with an area of normal rim activity), surgical flap intensity (as compared wtih normal rim activity), and other prominent features. The two sets of scans were placed side by side and scored for changes in size and intensity based on a scale of 3+ to 3— as described in Table 2.

RESULTS

Changes in lesion size and intensity, and in flap intensity, are summarized in Table 3. Although the

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TABLE 1. DISTRIBUTION OF PRIMARY BRAIN TUMORS STUDIED

Histologic diagnosis	Patients
Glioblastoma multiforme	12
Astrocytoma, grade III (anaplastic, gemistocytic)	26
Astrocytoma, grade II	4
Astrocytoma, cystic	1
Astrocytoma, cerebellar	3
Ependymoma	1
Medulloblastoma	5
Brain-stem glioma	2
Falx meningioma	1
Total	55

TABLE 2. SCORING OF CHANGES IN LESION SIZE, LESION INTENSITY, AND SURGICAL-FLAP INTENSITY

Score	Change
3+	Marked increase
2+	Small but definite increase
1+	Probable increase
0	No change
1—	Probable decrease
2—	Small but definite decrease
3—	Marked decrease

TABLE 3. SUMMARY OF SCORES

Changes in lesion size		Changes in lesion intensity		Changes in intensity of surgical flap	
Lesions	Score	Lesions	Score	Lesions	Score
3	(3+)	1	(3+)	3	(1—)
6	(2+)	15	(2+)	17	(2—)
2	(1+)	6	(1+)	15	(0)
34	(0)	26	(0)	20	Not seen
4	(1—)	1	(1—)		
1	(2—)	1	(2—)		
5	Not seen	5	Not seen		

majority of the 55 lesions showed no change in size, nine showed definite increase (2+ or greater), and one showed a definite decrease (2— or less). Changes in lesion intensity were more frequent, with 16 scoring 2+ or greater increase in intensity at 2 hr. Twenty-six patients showed no intensity change. In 17 patients, the surgical flap showed slight but definite decrease (2—) in intensity on the 2-hr scan, and three others showed probable decrease (1—). Figure 1 gives an example of a lesion that was scored 2+ for change in size, 0 for change in intensity, and 2— for change in intensity of the surgical flap. In

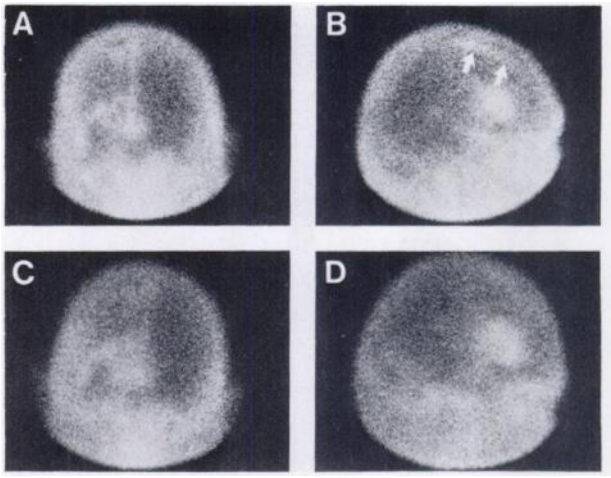

FIG. 1. Anterior (A) and right lateral (B) views 1 hr after injection. Note prominent flap activity (arrows). Corresponding views (C and D) 2 hr after injection. Note decrease in flap activity and increase in size of lesion, a malignant astrocytoma, with only minor change in intensity.

one patient a primary lesion was not detectable at 1 hr but was evident on the 2-hr image. In two instances a crescentic lesion was seen, but it was detectable only on the 2-hr view; in one the crescentic uptake was related to meningeal spread of tumor, and in the other it was caused by a subdural hematoma located under a surgical flap (Fig. 2). In five patients a lesion was not seen on either view, and in 20 no flap activity was identified.

In ten instances the lesion exhibited a doughnut sign at 1 hr, but more than half of these showed partial or total filling in of the central lucency at 2 hr (Fig. 3).

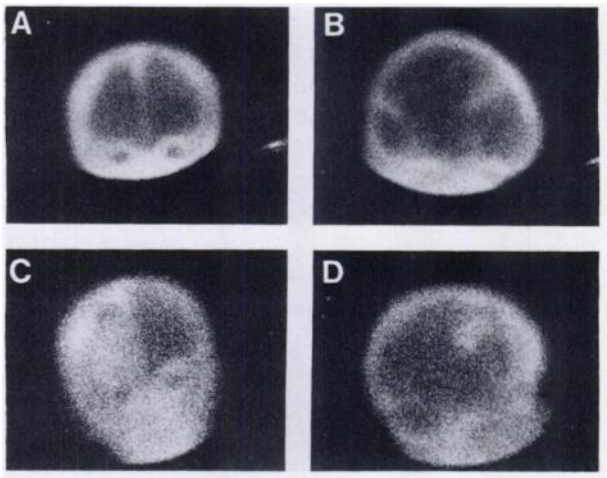

FIG. 2. Anterior (A) and right lateral (B) views 1 hr after injection in patient with left frontal malignant astrocytoma. Similar views (C and D) 2 hr after injection showing subdural activity that was not clearly seen in earlier images. This lesion proved to be a subdural hematoma under a bone flap.

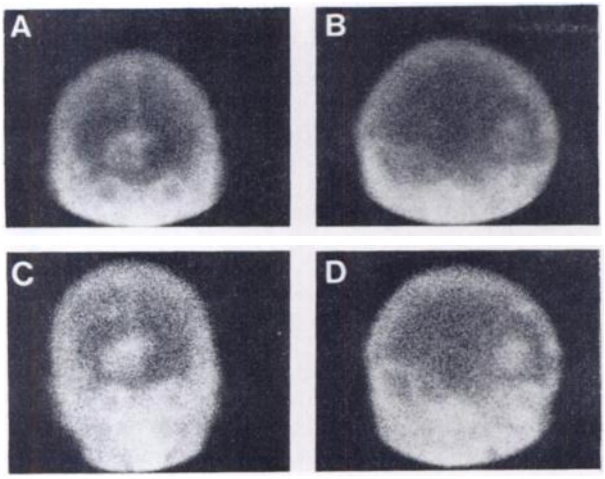

FIG. 3. Anterior (A) and right lateral (B) views of a right frontal glioblastoma with central lucency (doughnut sign) seen 1 hr after injection. Similar views (C and D) 2 hr after injection showing filling in of central area of decreased activity.

DISCUSSION

Chemotherapeutic agents have proven useful in the management of some patients with brain tumors (*2,3*). Successful management of these patients depends on careful monitoring of the effect of the agents on the lesions and early detection of tumor regression or regrowth (*4*). Levin and associates (*1*) have recently concluded that the neurologic examination and radionuclide brain scan are the most sensitive early detectors of tumor regrowth. Both tests detect early regression with a greater than 70% sensitivity, and regrowth with about 60% sensitivity. The CT scan was less sensitive for detecting regrowth (45%) and the EEG was less sensitive for either regression (20–30%) or deterioration (50%). The feature of the brain scan used for these determinations was change in lesion size.

One major problem encountered in evaluating lesion size in postoperative patients is the distinguishing of bone-flap activity from residual or recurrent tumor uptake. Increasing the delay period between injection and imaging is known to result in decreased intensity of surgical-flap activity (*5*). The strategy of increasing the delay period from 1 to 2 hr was designed to improve our ability to determine the true size of the lesion. We were interested, however, in other effects this change might have on the appearance of the lesion, especially changes in apparent lesion size.

Although most of the lesions showed no change in size, or only modest change (1+), in both views, a significant number did change. Sixteen percent (nine) showed a definite increase in size. In 29% (16) of our patients, the lesion-to-background ratio also showed a definite increase from the 1-hr to the 2-hr scan.

Slower accumulation of the tracer in the edematous region about the tumor may have been responsible for the increase in size of 16% of the lesions. One lesion showed a small but definite decrease in size; in this case, the activity may have been primarily due to increased blood pool in the lesion rather than a defect of the blood–brain barrier.

The majority of surgical flaps visible at 1 hr showed a decrease in activity at 2 hr. This finding was expected (*2*) and is probably related to decrease in the blood-pool activity.

The use of delayed scans for detection of subdural abnormalities has been reported (*6,7*). Wolfstein et al. (*8*) reported use of delayed Tc-99m DTPA brain scans in 126 patients. Their series, however, included only five primary brain neoplasms. Of these five, only one appeared on a delayed scan that was not visible in the earlier view; two of the five lesions were more obvious in the delayed scans.

Of interest were the changes observed in the doughnut sign. Only three out of the 10 lesions showed no change in the appearance of the doughnut over the 1-hr interval between the two studies. Two showed total filling in of the relatively cold area, and four showed partial filling in. In only one instance was the doughnut sign seen only on the 2 hr scan. The doughnut sign has been described in abscess, primary tumor, metastatic tumor, and stroke. This sign is presumed to reflect a necrotic or cystic central area, or a hemorrhagic component of the lesion (*9*). The filling in of the lucent centers in the lesions we saw may be related to slow diffusion of the tracer into the central area.

CONCLUSION

Our findings demonstrate the need for strict adherence to a specified time delay between injection and imaging in followup evaluation of brain lesions receiving chemotherapy. If our patients had been scanned initially at 1 hr and then, after a course of chemotherapy, scanned only at 2 hr, 16% of the lesions might have been falsely reported as enlarging lesions.

The 2-hr scan is preferred to the 1-hr scan. The activity of the surgical flap faded in about 50% of cases and the primary lesion showed increase in relative intensity in about 30% of cases on the 2-hr scan, significantly aiding the assessment of the intracranial disease. An unexpected advantage of the 2-hr scan was an increase in sensitivity, which resulted in detection of two recurrent tumors and one subdural hematoma that were not seen in the 1-hr scans.

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