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^{203}Mercury Brain Scans: The Use of Small Doses as a Screening Method

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Since Moore introduced ^{131}I flourescein brain scanning in 1948 (1), many techniques and a variety of radioactive agents have been used for the localization of intracranial space-occupying lesions (2-19). From 1954 to 1959, the most commonly used gamma-emitting isotope for brain scanning was ^{131}I as iodinated human serum albumin (RISA). In 1959, Blau and Bender (20) introduced ^{203}Hg labeled neohydrin and claimed significant improvement in tumor visualization (21). Confirmation of the value of ^{203}Hg neohydrin has been received from the reports of other investigators (22-31).

Despite improved methods and isotopic agents for brain scanning, tumors of the pituitary, third ventricle, brain stem and posterior fossae are difficult to detect (22-24). Moreover, the accuracy of diagnosis of brain tumors by radioisotopic scanning compared to standard roentgenographic procedures demands further attention. In this report we describe our experience with ^{203}Hg neohydrin scanning techniques with reference to these points and to the value of this method in the investigation of common neurological problems.

MATERIALS AND METHODS

Sixteen hours prior to the administration of radioactive ^{203}Hg neohydrin, 1 ml of mercuhydrin was given intramuscularly. A dose of 3-5μc of ^{203}Hg neohydrin (specific activity less than 0.05 mc/mg per kilogram body weight) was administered intravenously two to three hours before scanning.

The photoscanning system consisted of a 19-hole, 3-inch lead focusing collimator surrounding a 3-inch diameter thallium activated sodium iodide crystal. The distribution of radiomercury in the brain was displayed on both paper dot scans and as photographic images on x-ray film. An 80 kev window, centered on the 280 kev photopeak energy of ^{203}Hg was used on the pulse height analyzer. The linear scanning speed selected was 18 cm/min. An A/P and at least one lateral view were taken on all patients. P/A views were done on cases where posterior fossa lesions were suspected.

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The patients studied were referred from the neurological and neurosurgical services of the hospital and of the community. A few were referred from internists in the community. All referred patients were scanned. Nine patients were scanned as out-patients.

Full neurological examination of each patient was made by one of the authors, paying special attention to epilepsy and disorders of intellect, behavior, affect and speech. Patients in whom intracranial tumors were found were studied with respect to the following clinical factors: age, sex, race, intracranial pressure, the presence of physical signs and the rate of evolution of the illness. Contrast studies were performed on 28 patients with intracranial neoplasms. Of these, 18 had arteriograms and 5 had air encephalograms. Both procedures were performed on nine patients. Electroencephalograms were performed on 22 patients.

RESULTS

Of the 150 patients studied, 52 had abnormal scans (Table I). Of these, 39 were patients with neoplasms, two each with abscesses, chronic subdural hematoma and hydrocephalus and one each with angioma, aneurysm, subarachnoid hemorrhage (cause undiagnosed), hypertensive intracerebral hemorrhage, multiple sclerosis and lead encephalopathy (Table I). Ninety-eight scans were normal. Of these, 15 patients were without intracranial disease, 12 patients had intracranial tumors and the remaining 71 patients had various organic brain lesions (Table II).

Of 51 tumors in this series (Table III), 39 were correctly localized. In all but four of these, the lesion was seen in at least two views. In these four, all posterior fossa tumors, the lesion was clearly seen only in the P/A view (Fig. 1).

Of the 12 tumors that were not visualized by the scan (Table IV) one was a posterior fossa tumor in which a P/A view was not obtained and one was a left temporoparietal astrocytoma which was visualized by a second ^{203}Hg scan three months later. The others were all midline tumors in the region of the third ventricle. In these, a clinical diagnosis of metastatic carcinoma of the pituitary was made in two patients with a tissue diagnosis of the primary lesion. In the other seven, the situation of the lesion was established at operation, at autopsy or by contrast studies.

Attempts to correlate the pathological type of tumor and the features of cyst formation, necrosis, hemorrhage and vascularity with the result of the scan revealed no consistent relationships. None of the clinical factors studied were relevant to the visualization of the neoplasm. In two cases, one of hypertensive intracerebral hemorrhage and one of cerebral abscess, abnormal accumulations of radioactivity indistinguishable from those obtained in tumors were found (Fig. 2).

In the cases of intracranial tumor, arteriograms were abnormal in 19 of 25 (76%), air studies in 11 of 12 (91.6%) and EEGs in 10 of 22 (45.4%). Of the cases missed by the scan, one, a cerebello-pontine angle meningioma, was missed by the contrast studies. All the midline tumors were detected by air studies, half of them by arteriography and none by the scan.

There were 49 patients with convulsive disorders. Of these, 12 had brain

tumors. Of the remaining 37, 14 had focal signs or symptoms. All epileptics without neoplasia had normal scans whereas 11 of the 12 tumor patients had localized concentrations of ^{203}Hg. The single exception was a patient with a tumor located in the region of the third ventricle who had a fixed focal abnormality on EEG but no focal signs.

Of 51 patients who presented with disturbances of behavior, 27 had abnormal brain scans. Of these, 21 had intracranial neoplasms, two had hydrocephalus and one each had cerebral abscess, chronic subdural hematoma, angioma and hypertensive intracerebral hemorrhage. The patient with a chronic subdural hematoma, showed a picture analogous to that seen on an arteriogram with a clear area between the skull and surface of the hemisphere. The compressed hemisphere concentrated more radioactivity than the normal hemisphere (Fig. 3). Of the 14 patients with normal brain scans, there were five with vascular disease, three with degenerative disease and one each with closed head injury and posttraumatic epilepsy. Four patients of this group had intracranial tumors and normal scans. In three, the tumor was a midline tumor and the fourth was detected on the second scan three months later.

One patient who had a grade III astrocytoma detected by scan also had an incidental 1.5 cm diameter occipital meningioma at autopsy. Although a P/A view was not obtained, the meningioma was not detected by the scan. The smallest tumor detected in this series was a left parietal grade II astrocytoma measuring 1 cm in diameter in the fixed specimen.

TABLE I

A—NORMAL SCANS	98
Intracranial neoplasms	12
Other intracranial disease	71
Cranial and extracranial disease	6
Functional disease	9
B—ABNORMAL SCANS	52
Intracranial neoplasms	39
Hydrocephalus	2
Cerebral abscess	2
Angioma	1
Aneurysm	1
Subarachnoid hemorrhage	2
Intracerebral hemorrhage	1
Chronic subdural hematoma,	2
Multiple sclerosis	1
Lead encephalopathy	1

DISCUSSION

Seventy-six per cent of the tumors in this series were correctly localized compared with 56-93 per cent in other series (22-28). If the tumors are classified by anatomical situation, all but one of the tumors of the cerebral hemispheres and all posterior fossa tumors in which a P/A view was done, were correctly localized. All but one of the supratentorial tumors which were missed were

TABLE II

NORMAL SCANS

Intracranial tumors		12
Seizure Disorders		30
	Generalized seizures	16
	Focal seizures	8
	Posttraumatic epilepsy	6
Occlusive Vascular Disease		15
Vascular Malformations		4
	Aneurysm	1
	Subarachnoid hemorrhage	3
"Degenerative" Disease		10
	Senile dementia	3
	Presenile dementia	5
	Parkinson's disease	1
	Amyotrophic lateral sclerosis	1
Trauma (Closed Head Injury)		3
Other		24
	H. Flu Meningitis	1
	Migraine	3
	Adie's syndrome	1
	Diabetic 6th nerve palsy	1
	Tetralogy of Fallot	1
	Functional disorders	9
	Frontal osteoma	1
	Sciatic compression	1
	Polycythemia vera	1
	Cervical spondylosis	1
	12th nerve palsy with Horner's syndrome	1
	Multiple sclerosis	1
	Facial palsy	1
	5th nerve palsy	1

deeply situated midline tumors. In our hands, the ^{203}Hg scan was superior to the electroencephalogram and equal to contrast studies in the detection of hemisphere and posterior fossa neoplasms. It was inferior to both contrast studies and to the EEG in the detection of midline supratentorial tumors.

Our experience has been that if four scanning views are obtained, tumors in the cerebral hemispheres and posterior fossa will usually be found and supratentorial midline tumors are likely to be missed. Third ventricle or paraventricular tumors, other than aneurysms, are more likely to be detected by air studies

TABLE III

TUMORS DETECTED BY ^{203}Hg SCAN

Type	*Diagnosis*	*Situation*	*Views Displaying Tumor*
Cystic astrocytoma, grade 2	P.M.	R. fronto temporal	R. Lat. AP
Cystic astrocytoma, grade 2	Biopsy	L. temporal	L. Lat. AP
Astrocytoma, grade 2	Biopsy	L. parietal	
Astrocytoma, grade 3	Biopsy	L. temporal	L. Lat. AP
Astrocytoma, grade 3	Biopsy	R. parietal	R. Lat. AP
Astrocytoma, grade 3	Biopsy	R. temporal	R. Lat. AP
Astrocytoma, grade 3	Biopsy	R. frontal	R. Lat. AP
Astrocytoma, grade 3	Biopsy	R. temporal	R. Lat. AP
Astrocytoma, grade 3	Biopsy	L. parietal	L. Lat. AP PA
Astrocytoma, grade 3	Biopsy	L. parietal	L. Lat. AP
Astrocytoma, grade 3	Biopsy	R. frontal	R. Lat. AP
Astrocytoma, grade 4	Biopsy	R. temporal	R. Lat. AP
Astrocytoma, grade 4	Biopsy	R. frontal	R. Lat. AP
Oligodendroglioma	Biopsy	L. parietal	L. Lat. AP
Meningioma	Biopsy	L. parasaggital	L. Lat. AP
Meningioma	Biopsy	L. parasaggital	L. Lat. AP
Meningioma	Biopsy	R. parietal	R. Lat. AP
Acoustic neuroma	Biopsy	L. cerebellopontine angle	PA only
Hemangioblastoma	Biopsy	R. cerebellar hemisphere	PA only
Meningioma	Biopsy	Clivus	PA only
Pontine glioma	Contrast studies	Pons	PA only
Epidermoid carcinoma	Biopsy	L. parietal	L. Lat. AP
Metastatic melanoma	P.M.	Multiple	L. Lat. AP
Metastatic melanoma	Biopsy of primary	R. parietal	R. Lat. AP
Undifferentiated carcinoma	Biopsy	R. parietal	R. Lat. AP
Undifferentiated carcinoma	Biopsy	R. frontal	R. Lat. AP
Bronchogenic carcinoma	Clinical	Multiple	R. Lat. AP
Bronchogenic carcinoma	Clinical	L. parietal	L. Lat. AP
Bronchogenic carcinoma	Clinical	R. parietal	R. Lat. AP
Bronchogenic carcinoma	Clinical	Multiple	R. Lat. AP
Bronchogenic carcinoma	Clinical	R. temporal	R. Lat. AP
Bronchogenic carcinoma	Clinical	Multiple	R. and L. Lat. AP
Bronchogenic carcinoma	Clinical	Multiple	R. and L. Lat. AP
Carcinoma of Antrum	Biopsy of primary	L. frontal	R. and L. Lat. AP
Carcinoma of Colon	Biopsy of primary	R. parietal	R. Lat. AP
Carcinoma of Breast	Biopsy of primary	R. cerebellar	PA—both Lats.
Carcinoma of Bronchial Cleft	Biopsy of primary	L. frontal	L. Lat. AP

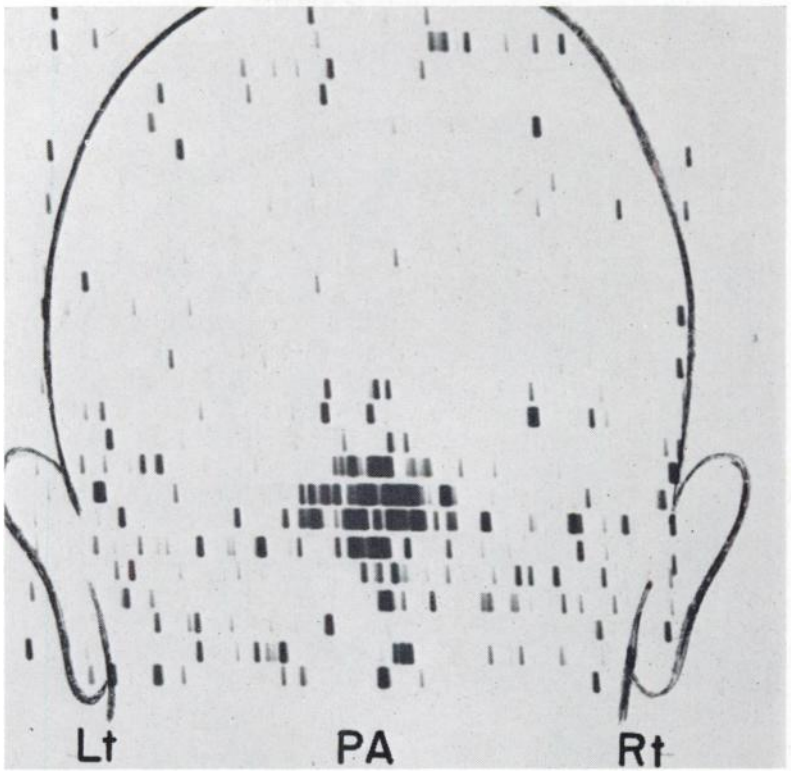

Fig. 1. Clivus Meningioma. Not seen on the lateral view. To illustrate the value of the P/A view.

TABLE IV

TUMORS UNDETECTED BY ^{203}HG SCAN

Type	*Diagnosis*	*Situation*
Colloid Cyst	Biopsy	3rd ventricle
Craniopharyngioma	Biopsy	Hypophysis
Cholesteatoma	Biopsy	Hypophysis
Midline tumor	Contrast studies	3rd ventricle
Midline tumor	Contrast studies	3rd ventricle
Metastatic carcinoma	Biopsy of primary	Hypophysis
Metastatic Carcinoma	Biopsy of primary	Hypophysis
Leukemic deposit	PM	L. Thalamus
Optic chiasm glioma	Biopsy	Optic chiasm
Meningioma	Biopsy	L. cerebellopontine angle (P/A scan not done)
Astrocytoma, grade 2	PM	L. temporoparietal (2nd scan positive)
Rathke pouch cyst	Biopsy	Hypophysis

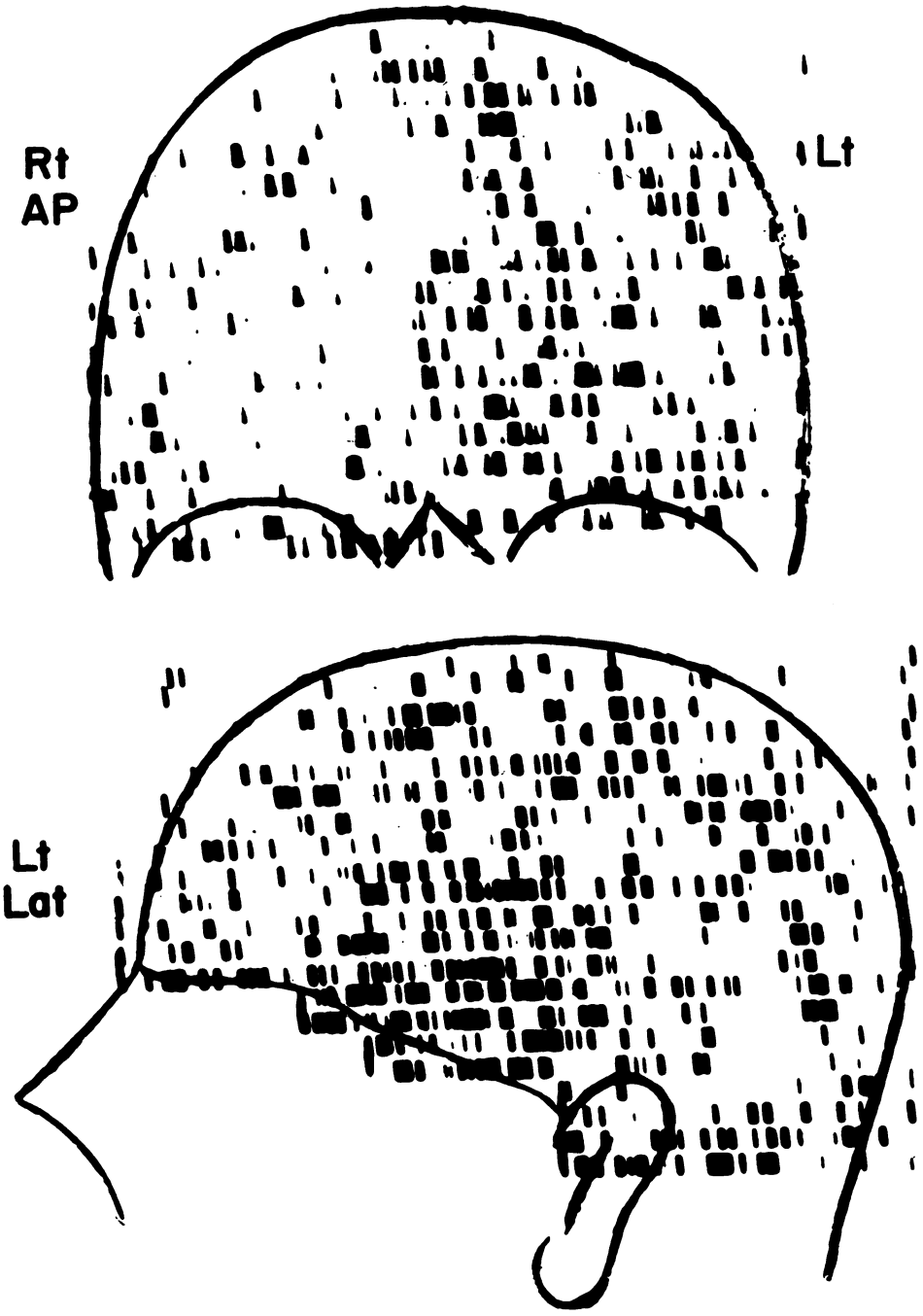

Fig. 2. Hypertensive intracerebral hemorrhage. To illustrate resemblance to neoplasm.

than by arteriography. Therefore, if an intracranial neoplasm is the probable diagnosis in a patient with a normal scan in all four views, an air study is likely to be the more useful contrast study.

The diagnosis of tumors from other abnormal scans caused difficulty in only two cases, an intracerebral hemorrhage (Fig. 2) and a temporal lobe abscess. In other cases, this potential difficulty was not a cause of real doubt, particularly in the light of the clinical and laboratory data.

The diagnosis of the type of tumor by an ^{203}Hg scan is unsatisfactory. Although meningiomata, the more malignant gliomata and metastatic tumors had greater concentrations of radiomercury than other tumors, we were not able to predict the type of neoplasm from the appearances of the scan.

The detection by an ^{203}Hg scan of a tumor must depend in part upon its size. Our data on this point are by no means satisfactory but tumors of 1.0–1.5 cm in diameter in the fixed specimen were both detected and missed. The tumor of the parietotemporal region, detected by a second scan three months after the first, measured 4 × 4 cm in the fixed specimen.

In the clinical diagnoses of the tumors in this series, six errors were made; in two cases of vascular disease a tumor was thought to be present clinically and in four cases a tumor was thought not to be present. In all six cases, the evidence of the scan compelled the alteration of the clinical diagnosis and instituted the correct management of the patient.

The disorders, other than neoplasms, which have been reported to cause accumulation of radiomercury are subdural hematomata, vascular malformations, hemorrhages, abscesses, degenerative disease and vascular occlusive disease (23, 24, 27, 28). In this series we found normal scans in all five patients with degenerative disease, in eight patients with occlusive vascular disease, six of whom had infarctions, and one each with multiple sclerosis and lead encephalopathy. Otherwise our results are in agreement with these previous investigations.

The P/A scan has been used extensively in this series and has proved of great value in localizing posteriorly-situated tumors, particularly those in the posterior fossa (Fig. 4). We have not seen all posterior fossa tumors on the lateral view because, it is thought, of the mass of overlying tissue and of the problems of collimation. The main difficulty in the interpretation of P/A films is the relatively high background activity and the frequent presence of a collection of radioactivity slightly to the side of the midline at the level of the lateral sinuses which we take to be the torcular (Fig. 5), on account of its frequent presence and constant position in normal and abnormal scans.

In many normal A/P scans, outlines of the ventricular system were observed. An enlargement of the ventricular contour permitted a diagnosis of hydrocephalus in one patient with severe hydrocephalus secondary to stenosis of the Aqueduct of Sylvius and in another with severe cerebral atrophy due to senile dementia. In many instances an evaluation of ventricular size could not be made by the brain scan. Similarly, gross displacement of the ventricles was easily recognized but minimal displacements were not. In particular, the absence of displacement could not be diagnosed from the scan.

The differential diagnosis of disturbances of behavior, particularly of presenile dementia, is one of the commonest problems in neurological practice and

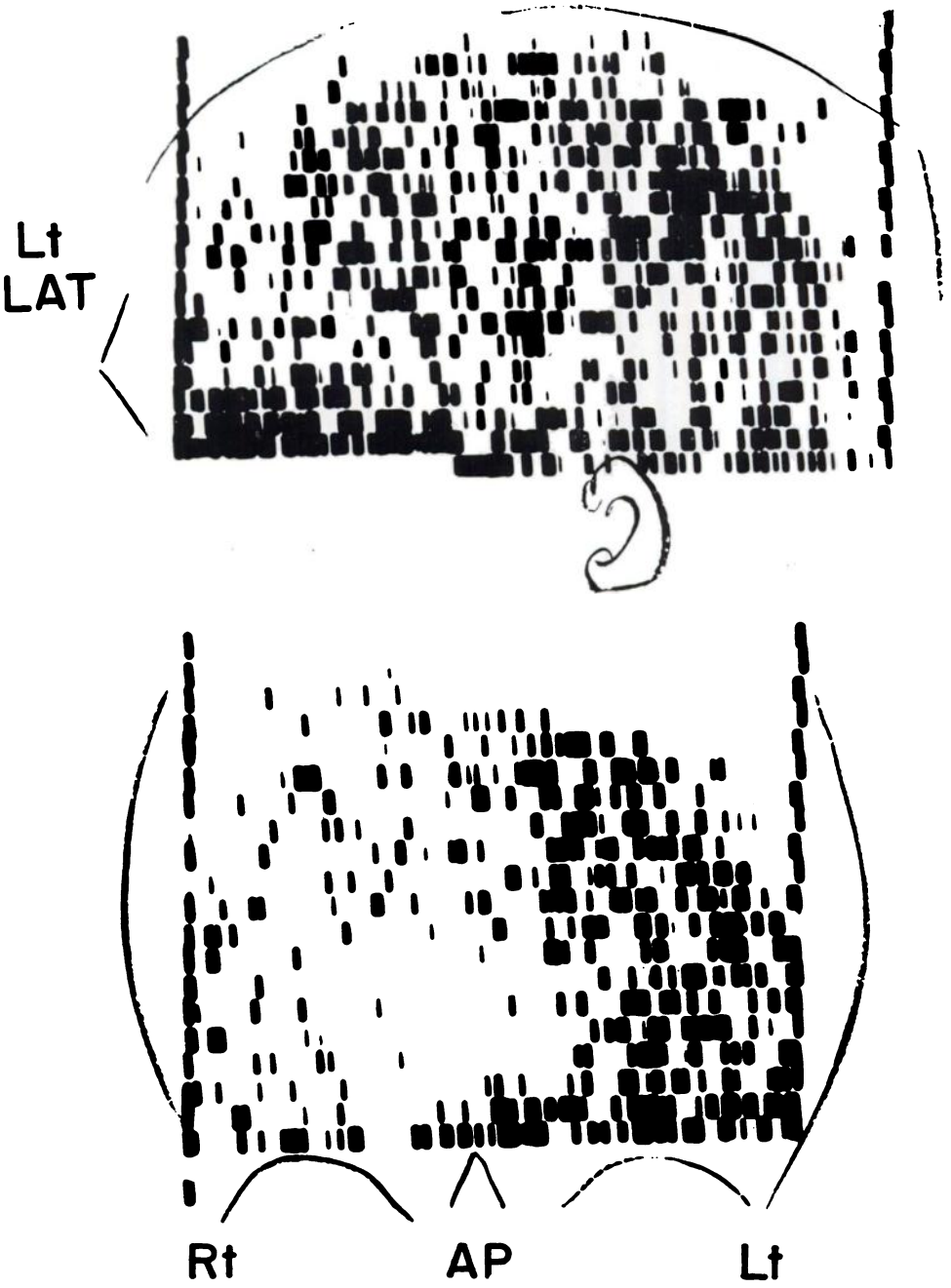

Fig. 3. Appearances of left chronic subdural hematoma with greater radioactivity in compressed hemisphere and none in the hematoma.

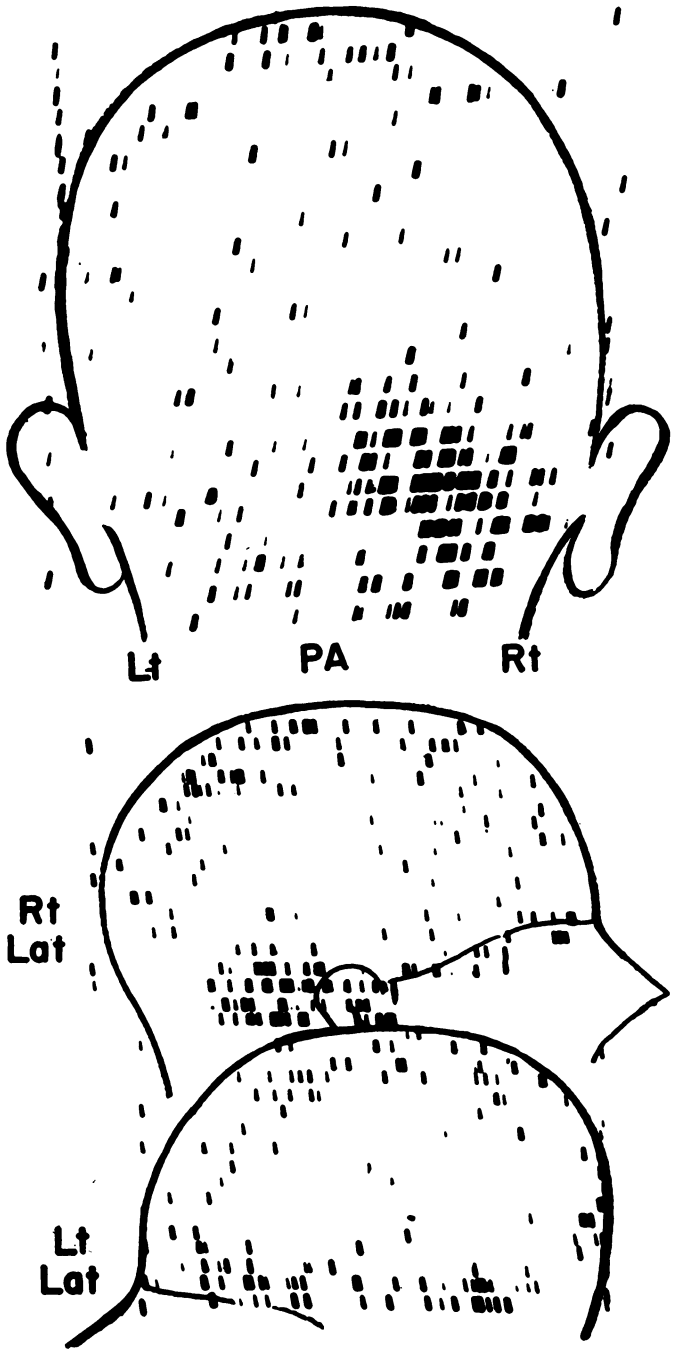

Fig. 4. Cerebellar hemangioblastoma. To illustrate value of P/A view.

includes such surgically remediable disorders as frontal meningiomata and hydrocephalus of varied origin. In this series, the scan demonstrated the lesion in 27 of 51 such cases, 21 of which were tumors, missing only four surgically treatable cases of which three were midline tumors and the fourth, a temporoparietal glioma, was demonstrated by a subsequent scan.

An equally, if not more, common symptom than disturbance of behavior is epilepsy of late onset. In this series, the scan detected eleven of twelve tumors in such cases. The seventh patient had a tumor in relation to the third ventricle. All other patients presenting with this symptom had normal scans. If these patients are grouped as those with and those without focal symptoms, the scan detected all the neoplasms among those with such clinical findings.

The scan has a great value in the management of patients presenting with one or other of those two symptoms. The problems are the selection of those in whom to advise contrast studies and which study to advise, knowing them both to be painful and dangerous. Further, patients are seldom willing to submit to a repetition. In contrast, the scan is painless, safe at any age, can be used on outpatients or the very sick and has a high degree of accuracy. These features eliminate the need for contrast studies in a number of patients and make it easier, when doubt exists, to decide which contrast study to do first.

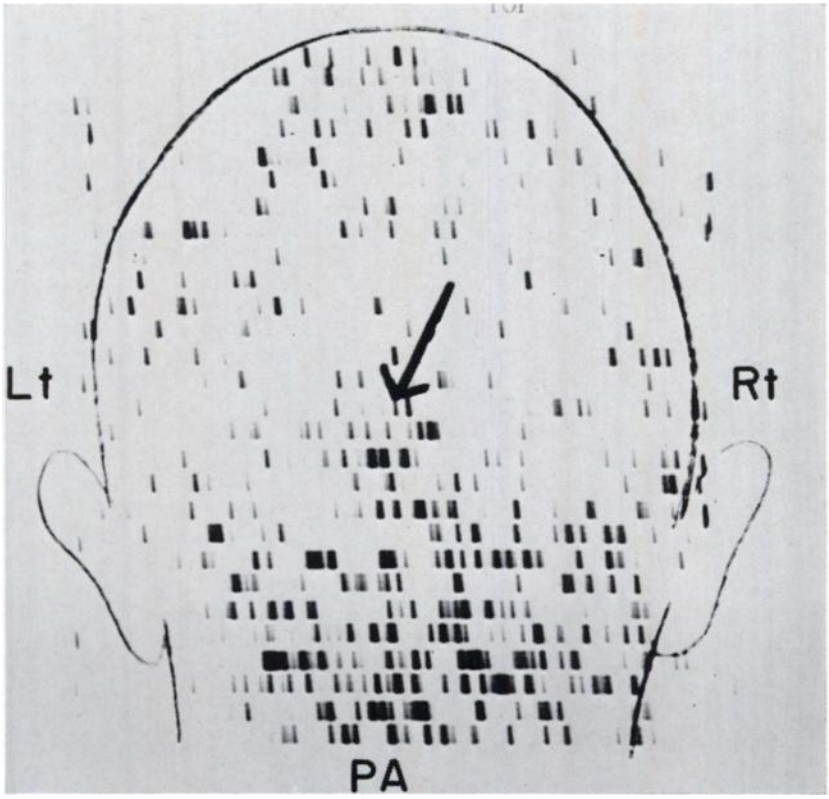

Fig. 5. Appearance of the torcular in the P/A view. The torcular may also be seen in Fig. 1, immediately above and slightly to the left of the tumor.

SUMMARY

This report describes a series of ^{203}Hg brain scans in which approximately half the previously reported doses of radioactive mercury were used. The use of the method as a screening procedure, particularly for patients with epilepsy of late onset and with disorders of behavior is discussed. All cases of epilepsy of late onset with focal symptoms or signs due to a neoplasm were detected. Of the tumors in this series all but one hemisphere tumors and all posterior fossa tumors in which a P/A view was done were detected. The value of the P/A view is discussed and the identification of the torcular is described.

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