

The Value of Brain Scanning in the Management of Strokes

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Abstract:
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■ The usefulness of brain scanning in the diagnosis and management of strokes was evaluated in 313 serial cases. Of 38 patients with transient ischemic attacks (TIAs), only one had a positive test. The optimal time for scanning completed strokes was between seven and 14 days after onset. The pattern of uptake was characteristic of a vascular lesion in 76.8%. When uptake was indistinguishable from tumor, follow-up scans were useful. Patients with negative scans in the second week have a significantly better prognosis than the ones with a positive study. Cerebral angiography and brain scan correlated well in 56 patients who had both tests performed. The postmortem findings in 12 cases again emphasize the importance of the correct timing of the study, and the fact that a brain scan does not usually demonstrate lesions smaller than 2 cm in diameter. It is concluded that the brain scan represents a useful tool in the diagnosis of strokes and helps in predicting the degree of recovery following a vascular insult.

Additional Key Words isotopic diagnosis prognosis cerebral angiography

□ The usefulness of isotope brain scanning in the diagnosis of neurological disorders is well established. The report of the Joint Committee for Stroke Facilities¹ recently stated that the "potential of the brain scan as a major diagnostic tool in dealing with stroke has been unrecognized." We, therefore, are reporting our scanning experience in a large unselected group of patients with clinical diagnosis of stroke in an attempt to define its applicability in the diagnosis and management of cerebrovascular accidents (CVA).

Methods

This study includes 322 patients with a clinical diagnosis of stroke studied by brain scan. Nine were found to have other neurological conditions and will be analyzed separately. The diagnosis in the remaining 313 cases was based on the clinical features and, in most of the cases, lumbar puncture and electroencephalograms were obtained. Angiography was performed in 56 patients. Seventeen patients died, and an autopsy was obtained in 12 of them.

A total of 379 scans were analyzed. Of the 322 initial scans, Hg¹⁹⁷ chlormerodrin (20 to 30 μ c per kilogram) was used in 291, Tc^{99m} serum pertechnetate (100 μ c per kilogram) in 16, and iodinated I¹³¹ sodium albumin (5 μ c per kilogram) in 15. Follow-up scans were obtained in 53 patients with stroke and in four patients with other diagnoses, as part of a prospective investigation of the evolution of brain scans in strokes.

Completed strokes (S) (symptoms lasting longer than

24 hours) were present in 275 cases, and 38 patients had transient ischemic attacks (TIAs) (deficits clearing within 24 hours). The great majority of the scans were obtained using a three-detector rectilinear scanner, with three-inch sodium iodide crystals feeding into a digital magnetic memory. The output was displayed on an oscilloscope and photographed. Two lateral views and a posterior view were obtained routinely; in some cases an anterior view was added. A few patients were scanned using a Picker Magnascanner.

Results

TRANSIENT ISCHEMIC ATTACKS (TIAs)

Brain scans were performed in 38 patients with TIAs. The mean age was 65.5 years. Scans were obtained between five and 15 days after the ischemic episode. The scan was positive in only one case (2.6%).

COMPLETED STROKES

There were 275 patients with completed strokes. The mean age was 65.3 years. Thrombosis was the presumed cause in 236 patients (85.8%), embolism in 33 (12%), and intracerebral hemorrhage in six (0.2%).

Isotope Used and Time of Scanning

In this group of patients the initial scan was obtained with Hg¹⁹⁷ in 250 cases, Tc^{99m} in 15 and I¹³¹ RISA in 10. There was no apparent difference in the three isotopes in respect to incidence of positive scans, timing of examination, or configuration of uptake. Positive scans occurred in 160 cases (58.2%). No positive scans were found in the first two days (fig. 1). The number of abnormal results exceeded the number of normal studies after six days, and after 12 days about 70% were abnormal.

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Pattern of Uptake

Three major types were found (fig. 2).

Type I — a "vascular" pattern was seen in 123 (76.8%).

Type II — a globular uptake, frequently in the temporal area and merging with the activity over the temporal muscle, was seen in 19.4%. In this group, the distinction between stroke and tumor was most difficult.

Type III — multiple areas of uptake without sharp definition were seen in 3.8%.

Follow-Up Scans

Repeat scans were obtained in 53 patients. Of the 46 scans initially abnormal, 25 became negative between 12 and 360 days after onset. Six patients with normal scans one to six days after onset had positive scans 9 to 25 days later. Among the 13 patients with Type II scans, indistinguishable from tumor patterns, seven became negative within seven to 180 days and five changed configuration to Type I.

Prognosis

We tried to determine whether or not patients with a negative scan had a better prognosis than the ones with a positive uptake. We were only concerned with the ischemic episode that led to the request for the brain scan, independently of the severity of the clinical

picture at the time of the study. We selected only patients in whom the brain scan was performed seven to 14 days after the onset of the symptoms, because we found that this was the optimal scanning time, and the patients were followed for six months. Of the 45 patients with a negative scan, 24 (53.3%) recovered markedly, while only 8.4% of the patients with an abnormal scan improved, a significant difference ($P < 0.05$). None of the patients with positive scans recovered completely and only six (8.4%) recovered to a useful point. In addition, 71.8% of these patients did poorly (this includes six deaths). If one considers the total number of patients who improved markedly or completely (30 patients), 80% had negative scans. On the other hand, of the 61 patients who did poorly after the stroke, 83% had positive tests.

Brain Scan and Cerebral Arteriography

Cerebral arteriography was carried out in 56 patients, with assessment of both intracranial and extracranial circulations in most patients. Brain scan and angiography were normal in six patients (10.7%), five of whom had an excellent recovery. Seven patients had normal angiograms and abnormal brain scans (12.5%) (five were Type I). Of 43 patients with abnormal arteriograms, 35 also had abnormal scans (62.5%). All patients showing "small vessel" disease (marked tortuosity and irregularity of the caliber of the intracranial arteries) had abnormal Type I scans. Occlu-

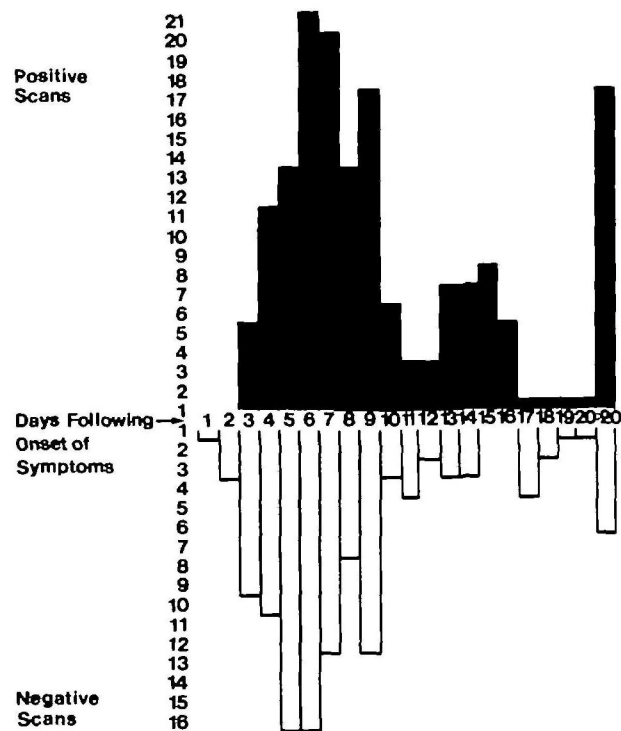


FIGURE 1

Incidence of positive and negative scans in relationship to the onset of the symptoms.

BRAIN SCAN IN STROKES**TYPE I - (76.8%)****Lateral View****Anterior or Posterior View****TYPE II - (19.4%)****Lateral View****Anterior or Posterior View****TYPE III - (3.8%)****Lateral View****Anterior or Posterior View**

FIGURE 2

Pattern of uptake in strokes.

sion of the internal carotid or its major divisions was seen in 21 cases, with abnormal scans in 17. Two patients had negative scans with occlusions of the middle cerebral artery. These scans were obtained only two and three days after the onset of the symptoms. Nine patients (including six with intracerebral hemorrhage) with angiographical evidence of an avascular mass had positive scans; seven of these were Type II. There was good correlation between the mass effect seen in the angiogram and the size and shape of the isotope uptake. As might be expected, this group of patients did poorly.

Correlation With Postmortem Findings

Correlation between the brain scan and the extent and location of the ischemic area was possible in 12 cases that came to autopsy (table 1). The brain scan was negative in five cases. In Case 12 no lesion could be found at autopsy which would explain the neurological findings. In Cases 4 and 8 the lesions were too small (less than 2 cm in diameter) to be disclosed by the scan. In Cases 3 and 7, the lesions were quite large but the scan was done two and three days after onset. In the remaining six cases correlation was excellent.

PATIENTS WITHOUT VASCULAR DISEASE

In nine patients other causes (three subdural hematomas, two meningiomas, three gliomas and one metastatic carcinoma) for their neurological symptoms were found by angiography, surgical exploration or autopsy. In all, the scan was abnormal and none was Type I ("vascular"). Serial scans in four patients one to 16 months apart showed no appreciable change in the uptake characteristics.

Comment

The value of brain scanning in the evaluation of strokes has been the subject of several reports.²⁻¹⁵ The patterns of uptake, the prognostic value of the test,¹ and correlations with angiographical or postmortem findings are points that deserve further clarification. We have noted that, in general, detection of vascular lesions does not depend on the type of isotope used, although in some instances serial scans with Hg¹⁹⁷ and I¹³¹ RISA have given useful diagnostic information.^{16, 17}

Of the cases with TIA, one had an unequivocally positive scan. This differs from the findings of other authors.^{7, 14} It is possible that a higher incidence of ab-

TABLE 1
Correlation Between Brain Scan and Postmortem Findings

Case no.	Day	Result	Brain scan		Autopsy findings
			Type	Location	
1	24	+	I	Frontotemporal	Encephalomalacia, frontal lobe and basal ganglia
2	9	+	I	Temporoparietal	Encephalomalacia, temporal and parietal lobes
3	2	-	-	-	Encephalomalacia, massive, parietal lobe and basal ganglia
4	6	-	-	-	Small lesion internal capsule (diameter <0.5 cm)
5	7	+	I	Frontotemporal	Encephalomalacia, basal ganglia, insula, inferior frontal gyrus
6	6	+	I	Frontoparieto-occipital	Encephalomalacia, multiple frontal, insula, posterior temporal and occipital lobes
7	3	-	-	-	Encephalomalacia, massive, basal ganglia and hemispheric white matter
8	7	-	-	-	Small lesion anterior thalamus (diameter 0.4 cm)
9	13	+	I	Frontotemporoparietal	Encephalomalacia, frontal parietal, temporal and occipital lobes
10	6	+	I	Frontoparietal	Thrombosis, internal carotid. Encephalomalacia, frontal and parietal lobes
11	5	+	I	Frontotemporoparietal	Thrombosis, middle cerebral artery. Encephalomalacia, frontotemporal and parietal lobes
12	5	-	-	-	No pathology found

normalities may be found by the use of isotopic angiography.¹⁸

Timing of the scan in relation to onset^{2, 7, 9, 11, 14, 19} also was obvious in the present series. After the twelfth day the incidence of positive scans was about 70%. Although some previous workers^{9, 11, 13, 18} called attention to some peculiar morphological features of the brain scan in strokes, others claimed that in most cases it is impossible to distinguish between CVA and tumors.^{7, 14, 20} This may in part be explained by differences in technique or timing, but in our experience, Type I uptake is a reliable indicator of the vascular nature of the lesion. Only rarely is it seen in other situations, and, in fact, was not encountered either in the nine patients with other diagnoses, or in 100 patients with metastatic disease reported elsewhere.¹⁷ We have found that infarctions in the distribution of the posterior cerebral artery may give rise to a positive scan. A Type II scan was seen in all our six patients with intracerebral hemorrhage in agreement with others.^{8, 10, 12}

The efficacy of isotopic diagnosis of stroke versus tumor was of particular interest to us. The morphology of the uptake was a useful clue, but the time of study and follow-up scans gave additional help. A negative scan in the first week that becomes positive a few days later, or a positive uptake that becomes smaller or eventually disappears in the presence of a neurological situation that has stabilized or is actually improving, are both suggestive of a vascular lesion. The pattern of uptake did not change in the nine patients without vascular disease. Follow-up scans were useful in stroke patients with isotopic patterns indistinguishable from tumors (Type II).

There is general agreement^{10, 11, 21, 22} that negative scans in stroke are associated with better prognosis, but there has been no study comparing the outcome of two groups of patients with positive and negative tests obtained within similar periods of time. Our study clearly demonstrates that a negative scan in the second week of disease is associated with a significantly better prognosis.

In 62.5% of the patients who had angiograms, both tests were positive. In contrast to previous studies^{8-10, 21} there was a good correlation between the results of both tests except in patients with extracranial vascular disease. We found that when the angiogram was normal, a Type I scan was quite suggestive of a vascular lesion. The chances of recovery were excellent when both tests were normal.

The 12 cases that came to autopsy again demonstrated the importance of the timing of the scan and the fact that lesions less than 2 cm in diameter are usually not demonstrable by this technique.^{19, 23, 24} Experimentally,²⁵ isotope uptake is highest in the areas of new capillary formation and within the macrophages that infiltrate the necrotic tissue. Both appear by the fifth day and persist during the dissolution and repair of the lesion.

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