JOURNAL OF NUCLEAR MEDICINE 6:902-916, 1965

Brain Scans at Varied Intervals Following C.V.A.

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THE EFFECT OF CEREBROVASCULAR ACCIDENTS ON THE BRAIN SCAN

Brain scanning is now a well established and commonly used clinical procedure, and its primary application has been for the diagnosis and localization of intracranial neoplasms. There is still relatively little known about this technique of demonstrating cerebral infarction secondary to cerebrovascular disease. The early reports of positive brain scans with cerebrovascular accidents were quite variable. Brinkman, *et al* (1) found no positive brain scans in eight patients with a diagnosis of cerebrovascular accident. However, by footnote they noted subsequent positive scans in one patient with frontal intracortical clot and one patient with middle cerebral artery thrombosis. Rhoton, *et al* (2) found six positive brain scans in sixteen patients with diagnosis of cerebrovascular disease. It was noted that four of the six positive scans did not have the well defined borders and characteristic spherical image that is usually seen with tumors. McGinnis, *et al* (3) also found abnormal brain scans in vascular occlusive disease, and noted the abnormal areas to be less well defined than in neoplastic disease. In April of 1964, following a "false positive" brain scan for a tumor, the present study was instituted to determine 1) the incidence of abnormal brain scan with cerebrovascular disease, 2) the time relationship between the cerebral insult and positive scans, and 3) any characteristics of the scan that might distinguish it from neoplasms.

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MATERIALS AND METHODS

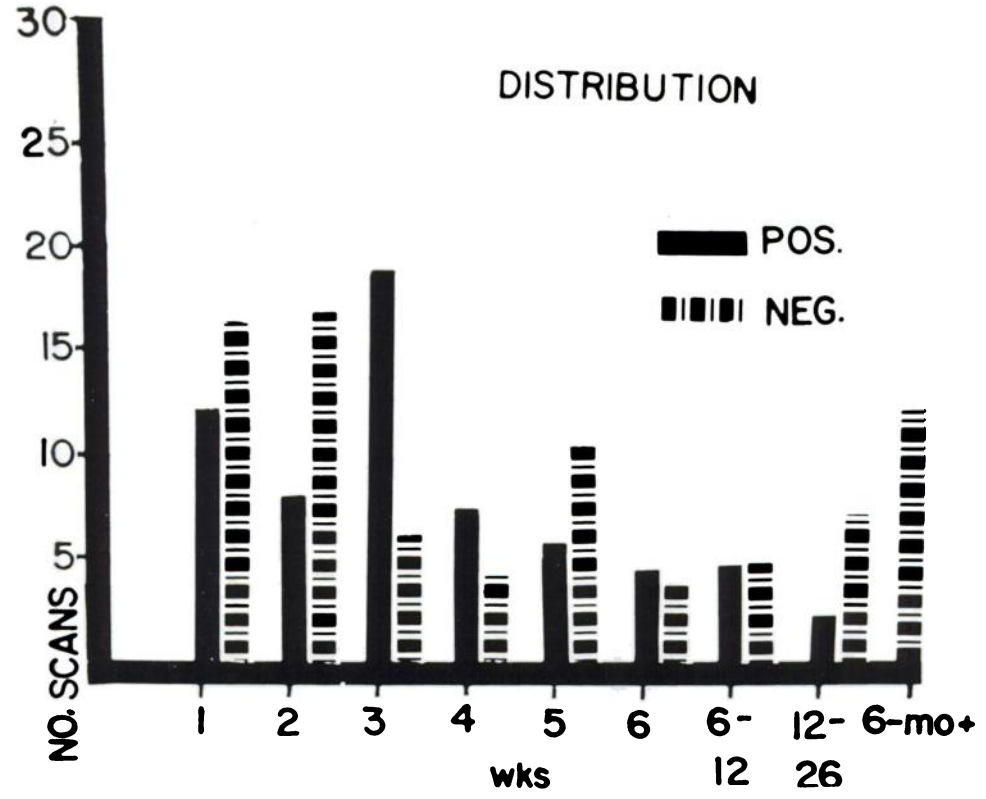
The cases reported are from two sources. All patients admitted with presumptive diagnosis of cerebrovascular thrombosis to the VA Hospital, Jackson, Mississippi, since April 1964 were scanned, then added to the study after the diagnosis was confirmed. A complete neurological examination was performed by one of the investigators (R.C.) and his impression and clinical location of the lesion were recorded prior to knowledge of the scan results. The scans were interpreted immediately. They were re-evaluated subsequently as a group without patient identification or clinical information, and there was good correlation to the first reading. There were 88 scans on 71 patients in this group. An additional 58 cases with a final diagnosis of cerebrovascular accident were obtained on review of 524 brain scans done since 1962 at the University of Mississippi Medical Center. Of the 146 scans included, 125 were performed with Chlormerodrin ^{203}Hg and 21 with Chlormerodrin ^{197}Hg. Scans were performed in the usual fashion with a blocking dose of stable Hg as Sodium Meralluride given intramuscularly several hours prior to intravenous injection of 600-700 μc of the labeled chlormerodrin. Scanning was performed 3-5 hours following injection of the isotope. At least two views were taken on each patient.

Because of the relatively high radiation dose to the kidneys with ^{203}Hg (4), it was not considered feasible to perform serial scans. However, scans were done at deliberately varying time intervals, and repeat scans were obtained in 17 cases. Spinal fluid examination was obtained in 94 patients, arteriograms in 40, and electroencephalograms in 50.

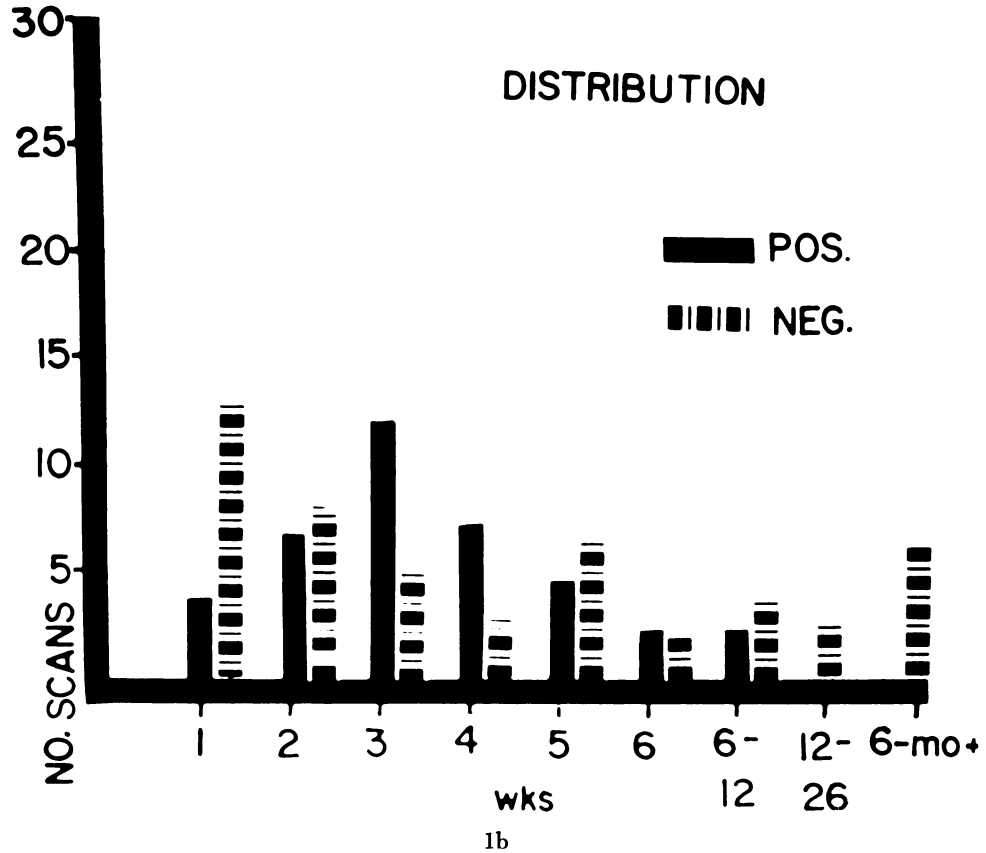
RESULTS

The overall number of positive scans, ranging from three days to several years post-ictus was 60 of 146, or 41 per cent. There was no positive scan after an interval of six months. Forty-five of 90, or 50 per cent of the scans performed during the first 28 days were positive. Three other scans were equivocal and eight suggestive during this same period. Figure 1a reveals the scan results related to time, while Fig. 1b shows the same data from the V. A. study alone. The peak incidence of positive scans appears during the third and fourth weeks, from 15 to 28 days, with a peak of 72 per cent during the third week. If only the patients with typical middle cerebral artery territory infarcts are considered, two of five scanned during the first week are positive; whereas, 19 of 22, or 86 per cent scanned from eight to 28 days post ictus were positive, indicating that a time interval is often necessary before the brain scan becomes positive. This is further illustrated by Fig. 2. These are scans on a 65-year-old male who entered with a classic left middle cerebral territory infarct with hemiplegia, a visual field defect and aphasia. Figure 2a is a scan seven days post infarct and was interpreted as within normal limits. Figure 2b ten days later, reveals a diffuse increase in the left hemisphere on AP, and a definite, but poorly outlined abnormal area of increased uptake on the lateral.

Figure 3 shows scans of a 69-year-old male who also entered with a classic left middle cerebral territory infarct. However, he had 3000 WBC per cu



1a



1b

Fig. 1. Distribution in results of (a) 146 brain scans of combined study and (b) 88 brain scans of VA Hospital group in patients with the diagnosis of cerebrovascular accident.

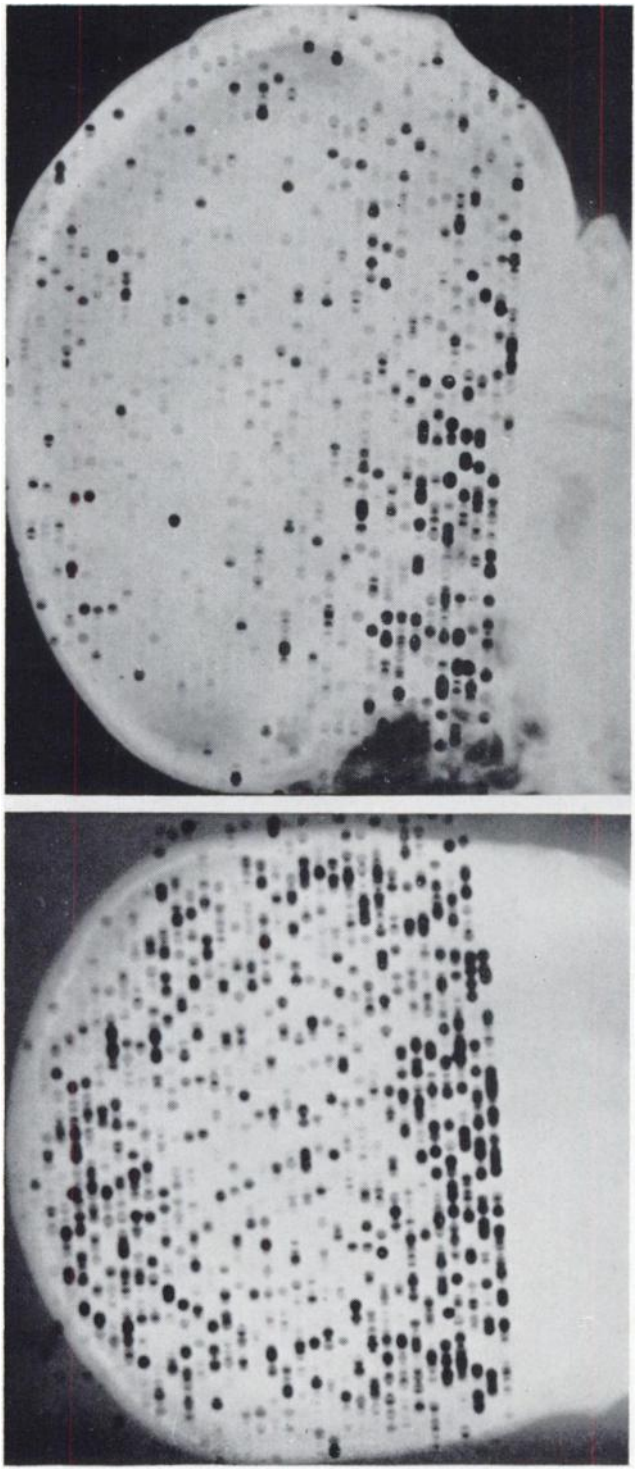


Fig. 2a. AP and left lateral brain scans seven days after the onset of symptoms of a left middle cerebral artery thrombosis.

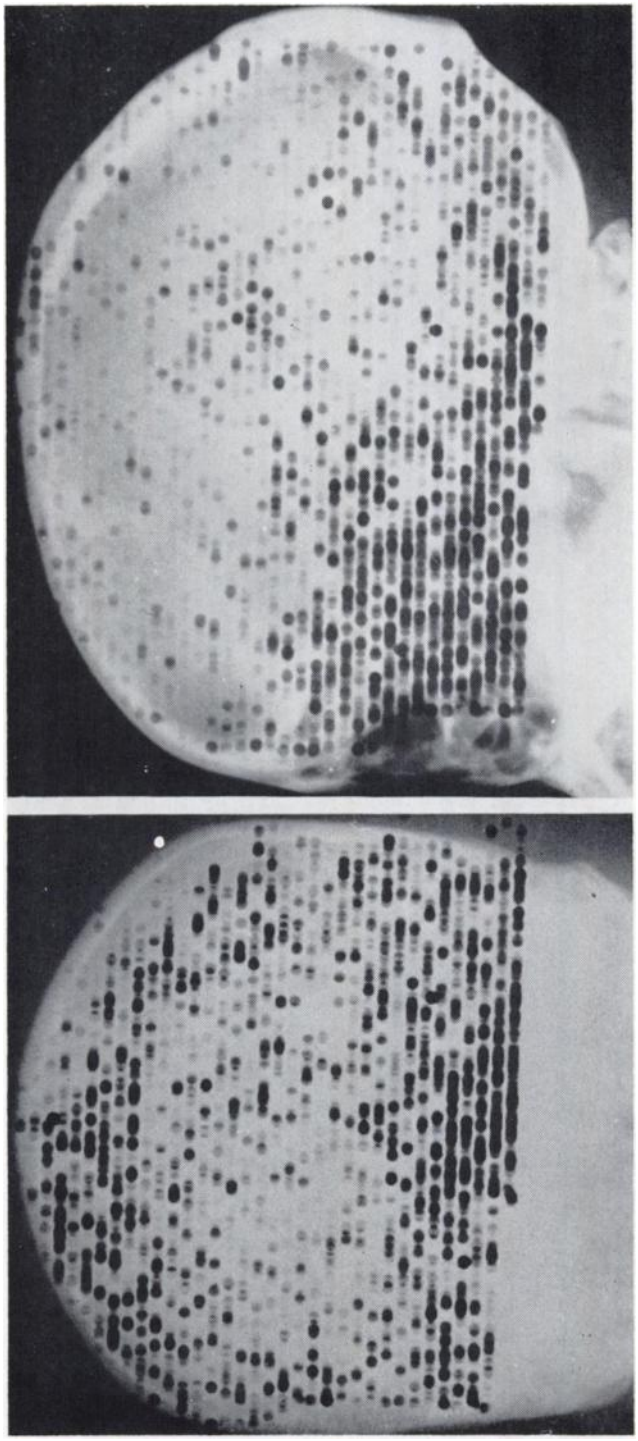


Fig. 2b. AP and left lateral brain scans, 17 days after the onset of symptoms of a left middle cerebral artery thrombosis. The abnormal area developed during the ten days between scans 2a and 2b.

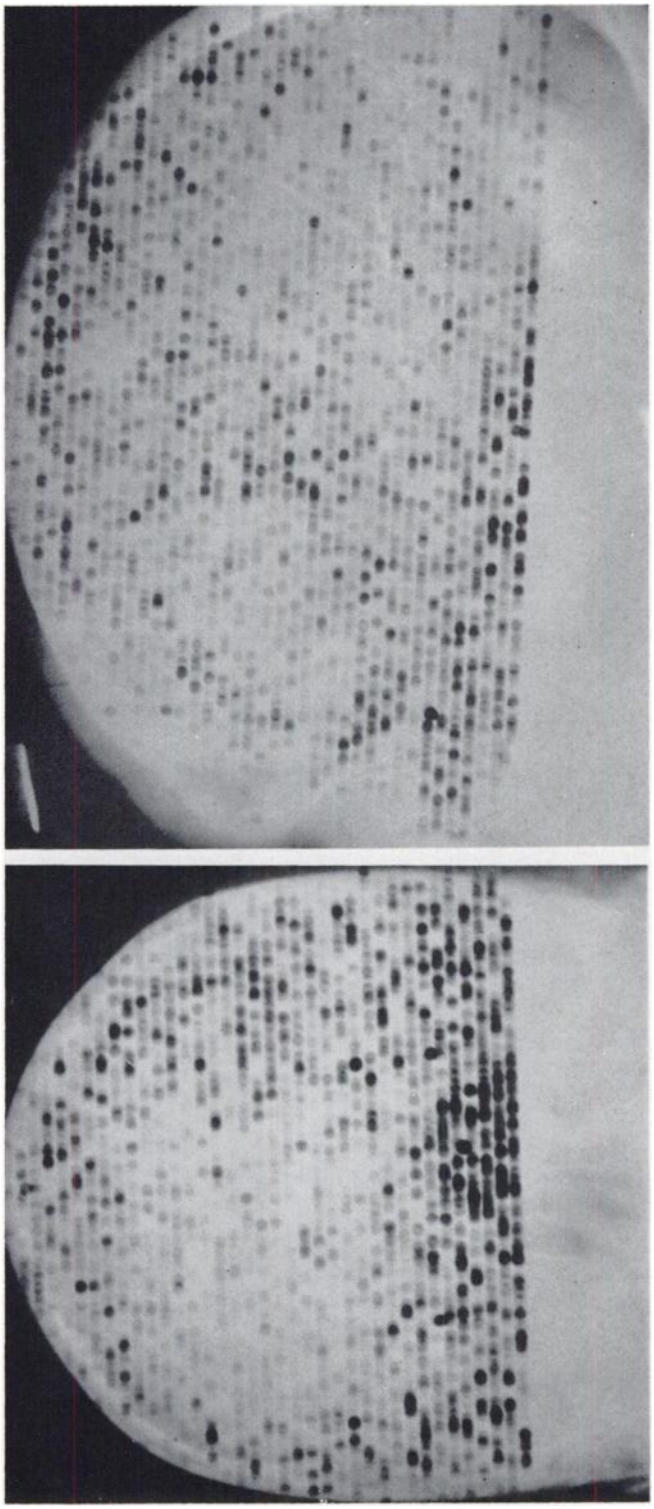


Fig. 3a. AP and left lateral brain scans three days following sudden onset of right-sided hemiplegia.

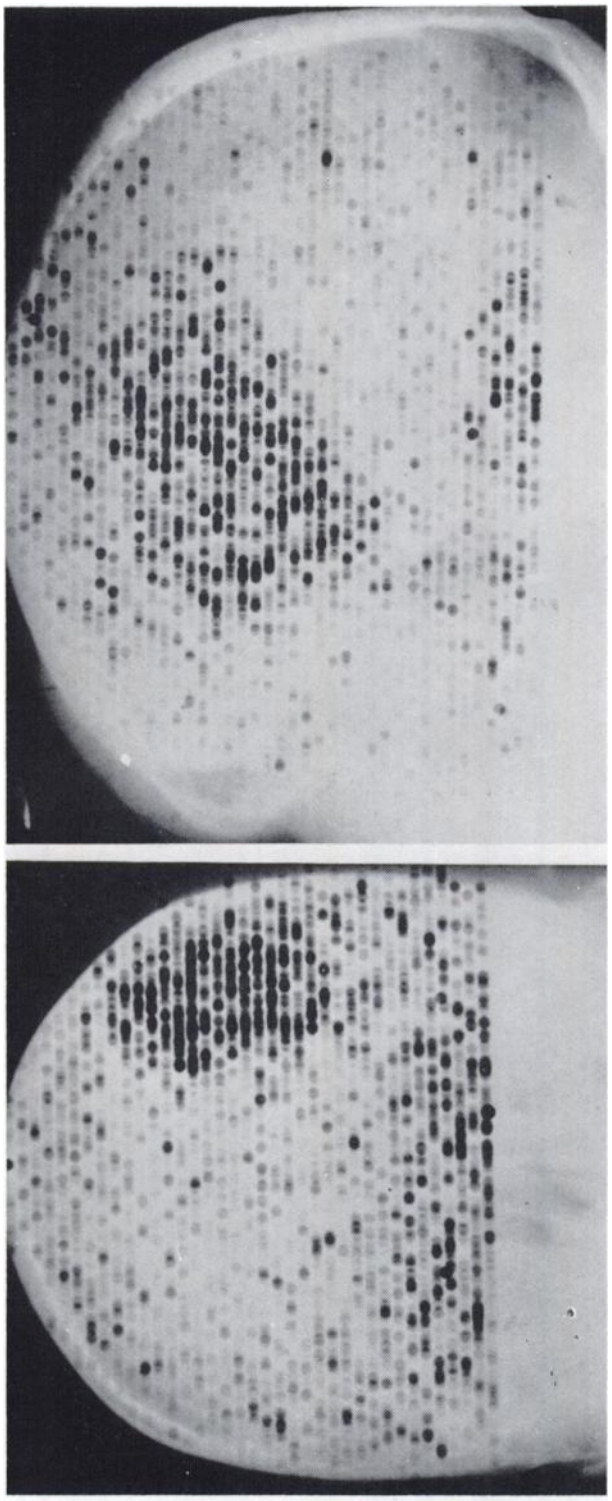


Fig. 3b. AP and left lateral brain scans 14 days following sudden onset of right-sided hemiplegia. Note the marked progression of the lesion in the 11 day interval between Fig. 3a and Fig. 3b.

mm in his spinal fluid. Figure 3a is scan done three days post infarct. This was interpreted as characteristic of cerebral infarct. The repeat scan, Fig. 3b, reveals a marked uptake consistent with tumor. EEG revealed delta waves in the left fronto-temporal area. Arteriograms were equivocal. A craniotomy was carried out and the brain biopsy revealed only cerebral infarct.

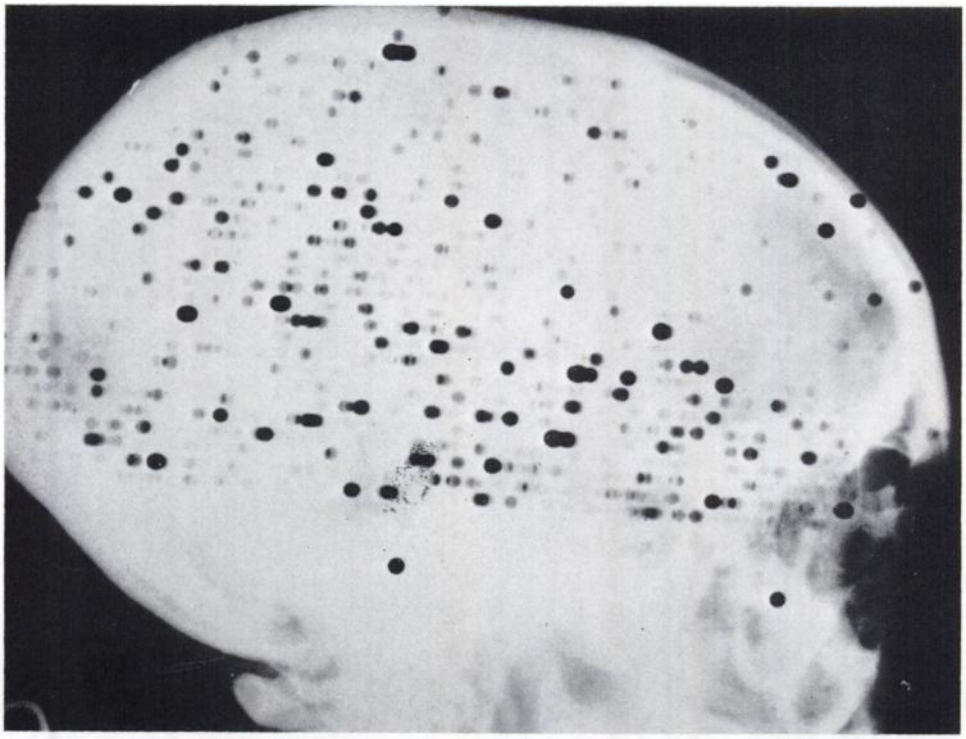
Figure 4 reveals the evolution of a right middle cerebral territory infarct, with Fig. 4a, 16 days post infarct, showing a poorly defined diffuse area of increased uptake forming a wedge from superior to the right ear posteriosuperiorly to blend with the scalp activity. Figure 4b, 42 days post ictus, reveals a smaller, more circumscribed area, again with somewhat indistinct borders, but with greater uptake. Figure 5 represents the scans on a 45-year-old male who entered with the sudden onset of aphasia and a right visual field detect without hemiparesis. Figure 5a is the initial scan performed at the eight day interval. It was felt to be consistent with tumor. Skull x-rays and cerebrospinal fluid studies were normal, and bilateral arteriograms revealed no evidence of tumor, but there appeared to be a partial occlusion of the vessels bilaterally. The scan in Fig. 5b, 33 days post ictus, is suggestive of some minimal residual uptake in the previously abnormal area, but was markedly improved and considered within normal limits.

Figures 6 and 7 represent lesions fairly characteristic of our series. Figure 6 is the scan of a 39-year-old male with the clinical diagnosis of a large right middle cerebral territory infarct with a left hemiplegia, a left visual field defect, and no aphasia. The scan was performed 19 days following the onset of symptoms. Figure 7 is the scan 15 days post ictus in a 73-year-old male who entered with aphasia only, with the clinical diagnosis of small left middle cerebral territory infarct, probably mainly parietal lobe. The wedge or oblong shape, ill defined borders, and uptake usually no greater than temporal muscle activity were typical of most of our positive scans.

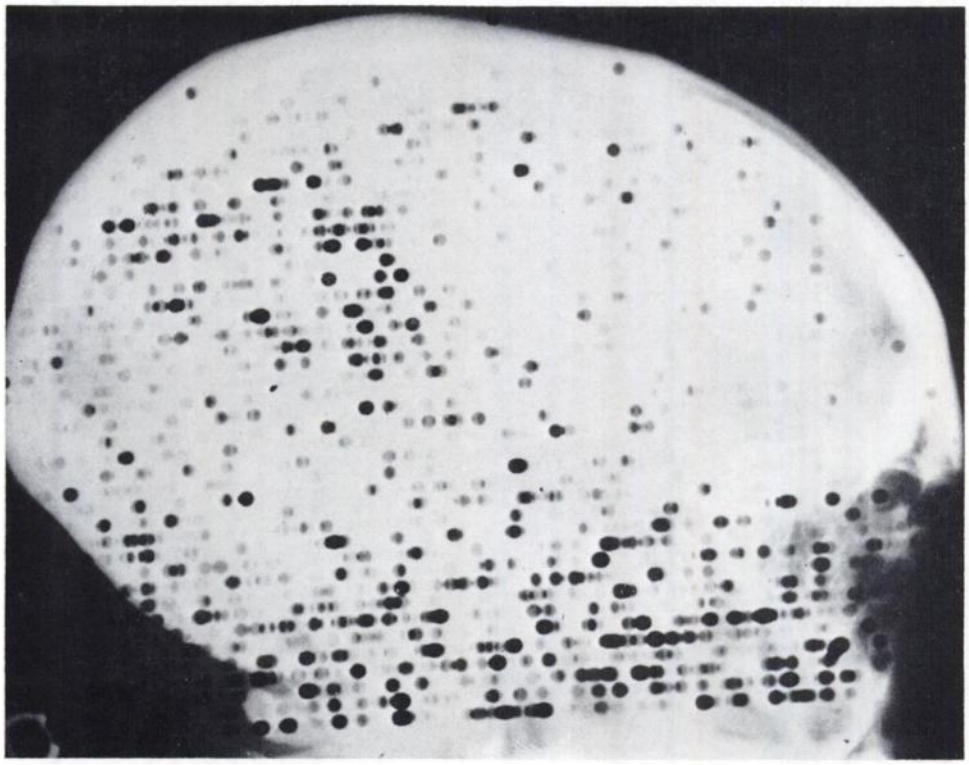
Figure 8 demonstrates the most massive lesion that was found. This scan was performed 12 days following the sudden onset of severe right hemiplegia, visual field defect and aphasia in a 44-year-old male barber, with onset while at work. A repeat scan 75 days following the onset of symptoms was much improved, but still definitely abnormal.

DISCUSSION

Although it has been recognized that a cerebrovascular accident producing cerebral infarction can cause abnormal brain scans, relatively little has been determined about the characteristics of this lesion. Morrison, *et al* (5) found 29 positive brain scans in 56 patients with a clinical diagnosis of cerebral infarction. Twenty-seven of the 29 positive cases were in the first four weeks. They concluded that the highest incidence of abnormal scans occurred in the early post infarction period and decreased with time. They also noted that in many instances the scan of an infarct appeared no different from that of a neoplasm, although infarcts tended to show an irregular area of uptake while tumors tended to have a more regular, rounded appearance.



4a



4b

Fig. 4. Right lateral brain scans at (a) 16, and (b) 42 days after right middle cerebral artery thrombosis. The lesion appears smaller and better demarcated on the follow-up scan.

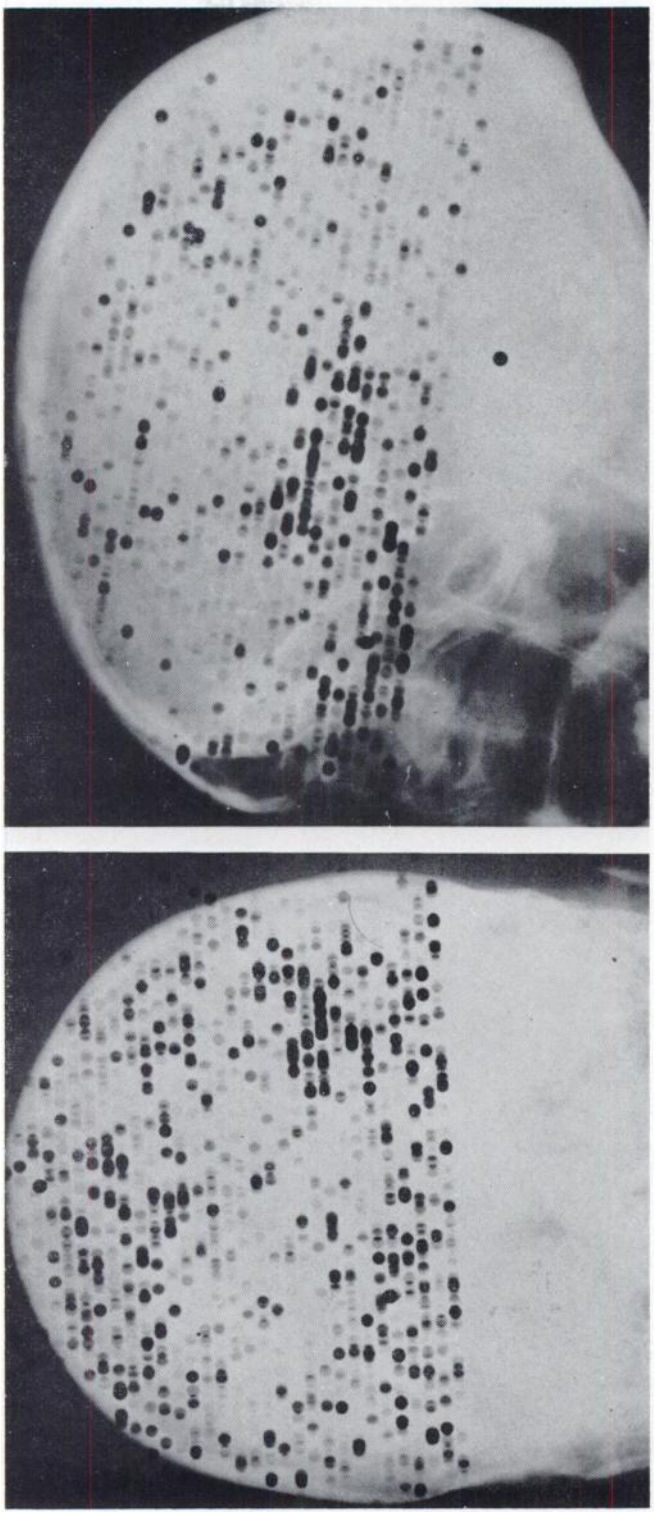


Fig. 5a. AP and left lateral brain scans eight days following sudden onset of aphasia and visual field defect.

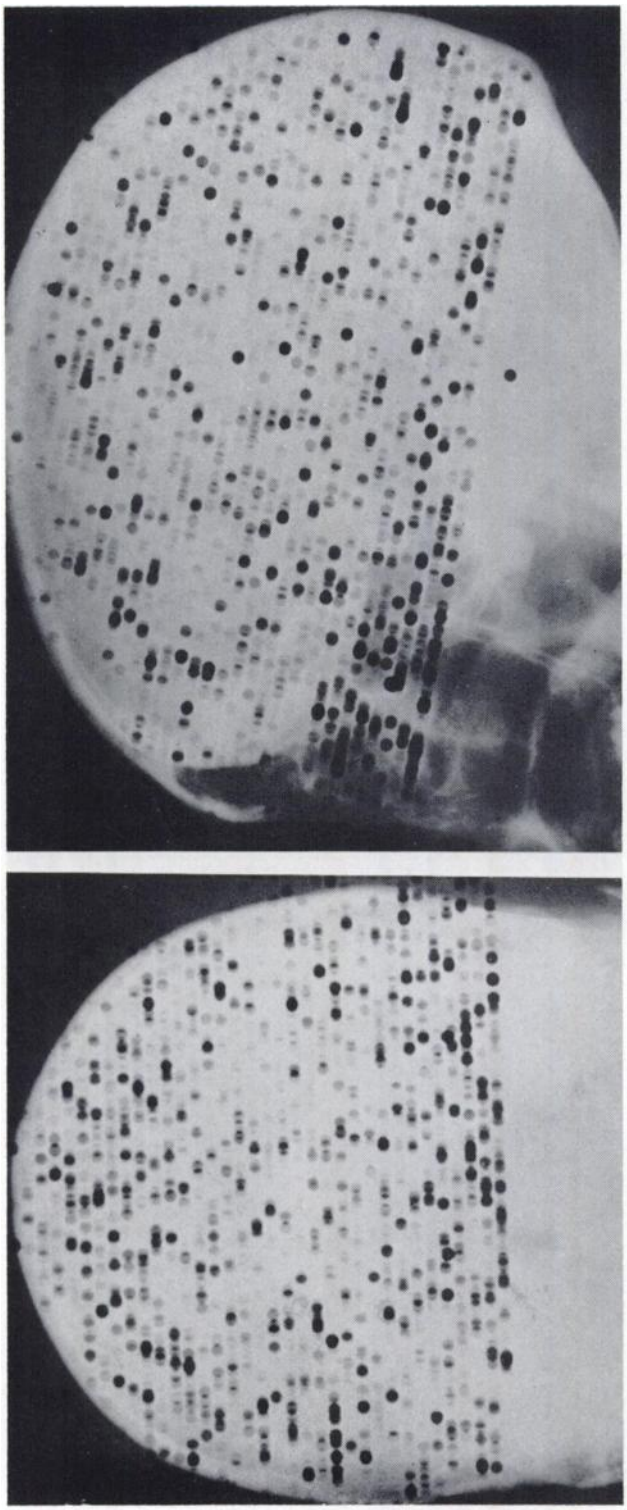


Fig. 5b. AP and left lateral brain scans (a) eight days, and (b) 33 days following onset of aphasia and visual field defect. The abnormal uptake on the initial scan has almost completely cleared on the follow-up scan, Fig. 6.

Waxman et al (6) reported 30 scans in 27 patients with cerebrovascular lesions, with positive scans obtained from four to 53 days after the clinical onset of the illness. A total of 17 of 20 cerebral infarcts, with hemisphere lesions, were accurately located by the scan. He states, "Because of the design of this experiment, the majority of positive scans was obtained during the first two weeks, but changes could still be seen in scans performed as late as 31, 33, 43, and 53 days post infarction."

In this study, the peak incidence of positive scans occurred during the third and fourth weeks post infarction. There was also good evidence that some scans which were negative or weakly positive during the first week, subsequently became positive. It appears that there is a definite but variable delay, in most cases, between the time of the cerebral insult and the positive scan. It also appears that the positive scan remains so for a significant, but variable length of time and that there tends to be a definite evolutionary pattern. The early positive scan appears to be a poorly defined diffuse abnormal area of increased uptake. This is followed by an apparent decrease in size of the lesion with better uptake and definition. At this point the scan of a cerebral infarct may closely resemble a tumor. Following this there is a gradual decrease in uptake in the abnormal area. The duration of this sequence appears to range from two through three weeks to as long as three through four months. There are not enough serial studies in the present study to be sure, but it appears that the early appearing small dis-

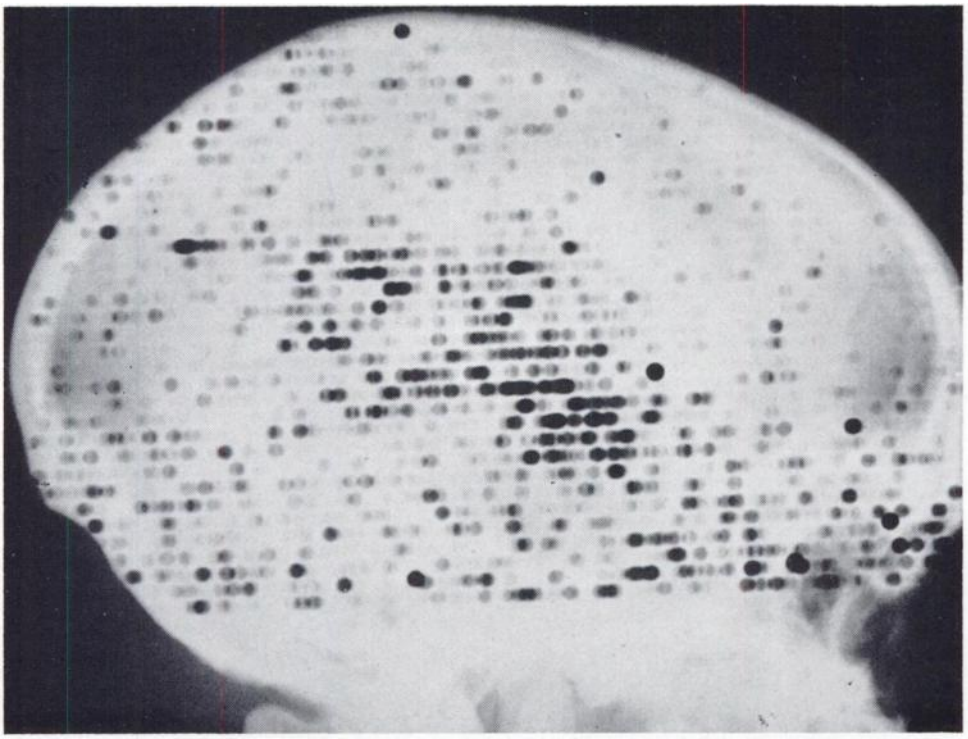


Fig. 6. Right lateral brain scan 19 days after onset of right middle cerebral artery thrombosis.

crete lesions tend to clear more rapidly than the more slowly developing ones. If this is true, it is of diagnostic importance since an early scan within the first week post ictus compared to a repeat scan in three weeks should reveal definite evolutionary changes.

The high incidence of positive scans in the third week is attributed to two factors, the earlier developing lesion is usually still abnormal at this time, and most later developing lesions will be at a detectable level. There was, however, definite progression after 21 days in some of the scans of large infarcts.

The apparent difference in time of peak incidence in this study and previous reports is attributed in part to a selection of cases. When reviewing scan records there is some selection, since most scans done on patients with a cerebrovascular accident are done because of a diagnostic problem. Such patients may not present a typical cerebrovascular thrombosis. However, the present series includes many typical "strokes".

Of the 71 patients in the V. A. group, only five scans presented any real problem of differentiation between infarct and neoplasm. (Figs. 3,5). One of these (Fig. 3) was partially clarified by the previous scan, but an abscess could not be ruled out. Craniotomy was performed in this case. The characteristics of the cases which could be differentiated were typical configuration and distribution of the abnormal area, the relatively slight increase in uptake as compared

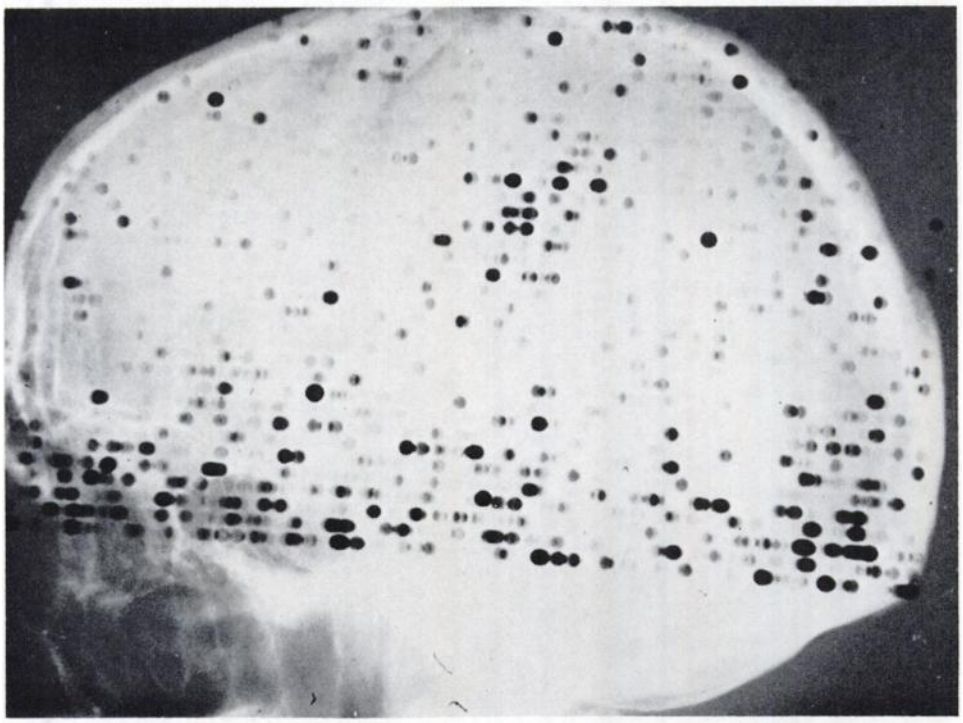


Fig. 7. Left lateral brain scan 15 days following sudden onset of aphasia.

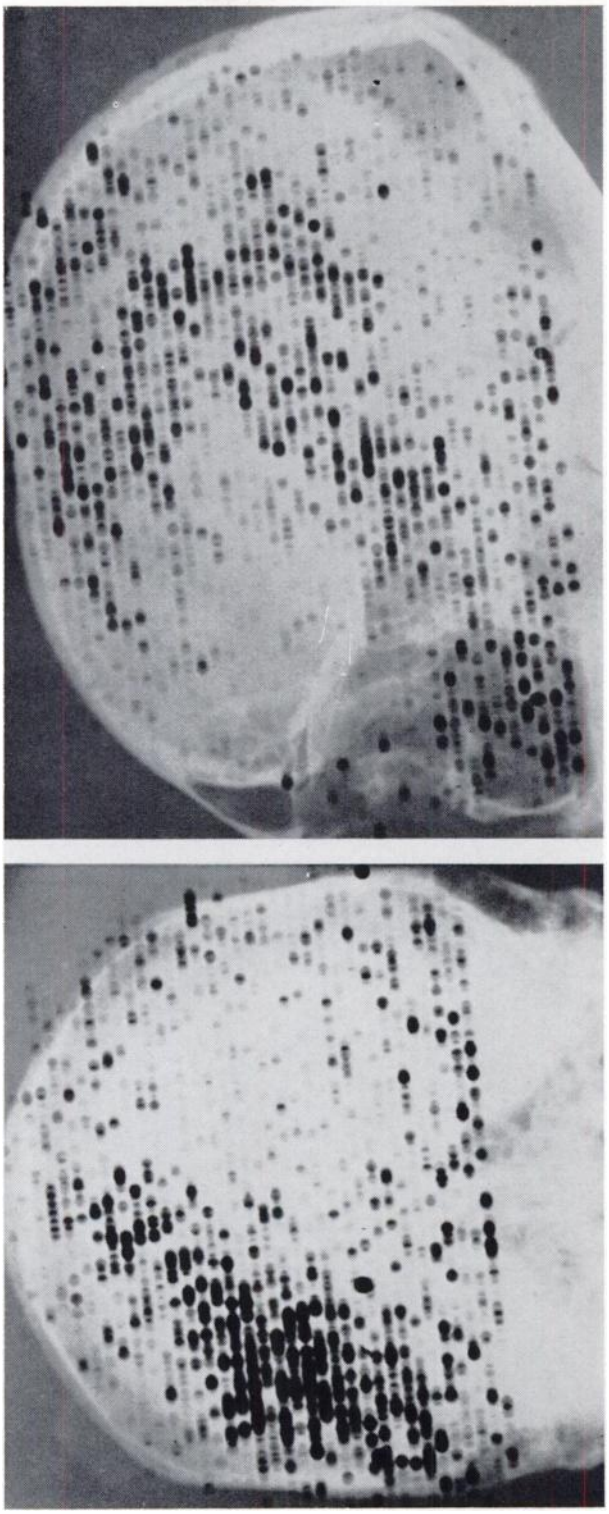


Fig. 8. AP and left lateral brain scan 12 days after onset of clinically-large left middle cerebral territory infarct.

to tumor (usually no greater than scalp and muscle background), and the diffuse, ill-defined borders of the lesion, in one or more views.

There are several theories to explain the uptake of radioactive material by damaged brain tissue (6, 7). These include breakdown of blood brain barrier, with increased capillary permeability, cerebral edema of surrounding tissue with accumulation of the radioactivity in the interstitial fluid, and increased vascularity. Two factors are suggestive of increased vascularity when it plays a role in the abnormal uptake found in the ischemic infarct. First, the apparent interval between the onset of clinical symptoms and the positive brain scan is consistent with the time required in the healing of the infarct for the development of new capillary network and gliosis. Second, the density of the abnormal area on the scan following cerebrovascular accident is usually no greater than the density of the vascular areas such as scalp and muscle activity.

SUMMARY

One-hundred and forty-six brain scans were performed on 129 patients with the clinical diagnosis of cerebrovascular accident. The highest incidence of positive scans was in the third week after the infarct when 18 of 25 cases were found positive. By repeat scanning on some of the patients a delay in development of a positive scan after the infarct was demonstrated and an evolutionary pattern could be seen. Although some of the scans were indistinguishable from neoplasm, the majority in this study had a characteristic distribution and configuration, ill-defined borders, and the uptake was less than is usually seen in neoplasms of similar size.

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