Scanning with Positron-Emitting Radioisotopes: Aneurysm, Arteriovenous Malformation and Intracerebral Hemorrhage*

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Positron-emitting isotopes arsenic-74 and copper-64 are used to perform radioisotopic brain scans at the Massachusetts General Hospital. From 1958 to 1963 a total of 61 scans was done on 55 patients with confirmed diagnoses of aneurysm, arteriovenous malformation, and subarachnoid or intracerebral hemorrhage (Table 1). In this report the appearance of the scan, the degree of neurologic deficit, the interval of time from onset of symptoms to scan, and the angiographic and pathologic findings are correlated. In a companion paper, the findings were reported in 146 cases of occlusive cerebral vascular disease studied similarly.

Previous reports of radioisotopic brain scans in patients with aneurysm, arteriovenous malformation, and subarachnoid or intracerebral hemorrhage are summarized in Table 2. Our report in 1959 included As74 scans in 7 of 12 patients with demonstrated aneurysms and 2 normal Cu64 studies. Paul and Botterell24 reported a positive scan with As74 in a patient with a vertebral arterial aneurysm, but there was "some question as to the boundary of concentration." With radioactive iodinated serum albumin (RISA) Planiol and Gauthier25 reported 3 positive studies in 13 cases of "arterial aneurysms" but size and location of the aneurysm and neurologic status were not indicated. Di Chiro26 noted an abnormal scan in a case of aneurysm of the internal carotid artery. McAfFee and Taxdal26 found the procedure of no value in the detection of aneurysms up to 1 in. in diameter. Brinkman et al.4 using Hg200 found a positive scan of an aneurysm measuring 5×4 cm. A poorly defined area of increased concentration of mercury-203 around an aneurysm of the anterior communicating artery was illustrated by McGinnis and co-workers.17 In total, 17 of 44 radioisotopic scans in patients with known intracranial aneurysms were reported as normal.

In patients with arteriovenous malformations, increased concentration of RISA was found in most of the cases. Planiol and Gauthier25 noted a definite abnormality in 24 of 28 angiomas. One normal scan was seen by Dunbar and Ray49 in a patient with a small malformation close to the midline. Feindel and co-workers9 reported a case of extensive left-sided angioma. Immediately after injection a single detector recorded a high peak of activity in the central region over the vascular malformation. Low counts were recorded over the rest of the head. Differential concentration which developed immediately after injection persisted almost unchanged in the 48-hour scan. This finding also was noted by Merchie and Mouchette20 in a 24-hour scan. Askenasy and co-workers,1 using fluoroborate labelled with fluorine-18, scanned 4 patients with vascular malformations. In 2 positive studies the "blood content of the affected area was significantly different from that of the normal tissue." In the 3 positive Hg200 scans reported by Dugger and Pepper9 it was necessary to start the scan a few minutes after injection because of the rapid loss of activity from the abnormal area. The picture obtained was found to be more diffuse and less striking than that seen
In our previous reports,\textsuperscript{6,29} 5 of 8 intracerebral hemorrhagic masses studied with arsenic were localized correctly, whereas 2 of 3 were missed with copper. Feindel \textit{et al.}\textsuperscript{12} with the use of RISA located a moderate increase of activity in the midfrontal region 15 days after the onset of an intracerebral hematoma. At operation it was noted that the area of isotopic concentration seen in the scan was smaller than that involved by the hemorrhage. They concluded that the uptake of isotope depended mainly on recent blood or edema in the brain tissue adjacent to the clot. Another patient, with a 4-week-old intracerebral hematoma, had a technically unsatisfactory scan, but isotopic concentration was determined at operation. A sample taken 30 hours after injection revealed that the hematoma contained only 2 per cent of the activity of a venous blood sample compared with a 15 per cent figure in normal tissue. Mastropaolo and Dacquino\textsuperscript{19} noted the transient appearance of hyperactivity at the site of hemorrhage in scans of 3 patients, 3, 4 and 7 days after injection of \textsuperscript{111}In. Immediately after injection in 2 of these cases, increased concentration was noted in the opposite hemisphere. In summary, 21 of 31 intracerebral hematomas were associated with an increased isotopic concentration.

\textbf{Method}

Previous reports have discussed the use of positron-emitting isotopes for localization of focal intracranial lesions.\textsuperscript{2,19} Two isotopes, arsenic-74 as sodium arsenate, and copper-64 chelated with diethylene-triamin-pentacetic acid, have been used most frequently.

Localization with positron-emitting radioisotopes utilizes the peculiar physical properties of the positron-electron process of annihilation. This yields a pair of oppositely directed gamma rays which are recorded when they hit a pair of detectors in time coincidence. The record of this coincidence is called a positrocephalogram. In addition, the difference in total gamma activity between one side of the head and the other may be recorded. This unbalance scan, or asymmetrogamagram, indicates the asymmetry of a concentration of activity which is right- or left-sided. The two scans are printed simultaneously by mechanical printers connected directly to the heads of the moving detectors so that a full-sized picture is available immediately. For confirmatory and more precise lateralization an anteroposterior view usually is obtained.

The radioisotope is administered by intravenous injection, and the scan is usually performed about 1 hour after injection.

Scans are interpreted by describing the locus of the concentration and the degree of abnormality is indicated on a 1 to 4 numerical scale: 1 indicates a definitely abnormal scan; 2, probably abnormal scan; 3, probably normal; and 4, a definitely normal scan. For statistical purposes 1 and

\begin{table}
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\caption{Radioisotopic scans in patients with aneurysm, arteriovenous malformation, subarachnoid hemorrhage and intracerebral hemorrhage}
\begin{tabular}{|l|c|c|c|c|}
\hline
\textbf{Disease Category} & \textbf{Arsenic-74} & \textbf{Copper-64} & \textbf{Total} \\
& \textbf{Abnormal} & \textbf{Normal} & \textbf{Abnormal} & \textbf{Normal} \\
\hline
Aneurysm & & & & \\
With subarachnoid hemorrhage and neurologic deficit* & 8 & 3 & 1 & 2 & 14 \\
With subarachnoid hemorrhage and palsy of 3rd nerve\dagger & 0 & 1 & 0 & 2 & 3 \\
Without subarachnoid hemorrhage & 3 & 0 & 1 & 0 & 4 \\
Subarachnoid hemorrhage of unknown etiology & 1 & 5 & 0 & 1 & 7 \\
Arteriovenous malformation & 3 & 1 & 0 & 1 & 5 \\
Intracerebral hemorrhage & 12 & 5 & 4 & 7 & 28 \\
\hline
\textbf{Total} & 27 & 15 & 6 & 13 & 61 \\
\hline
\end{tabular}
\end{table}

* Neurologic deficit indicates clinical evidence of injury to cerebral tissue with or without peripheral abnormality of cranial nerves.

\dagger Palsy of the 3rd nerve was the only neurologic abnormality.