ASSESSMENT OF CEREBRAL LESIONS BY RAPID SEQUENTIAL SCINTIPHOTOGRAPHY

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Until the advent of rapid sequential scintiphotography, information regarding regional cerebral blood flow has been obtained by monitoring the passage of radioisotope tracer injected via the internal carotid artery with several large or many small scintillation detectors (*1*). Radioactivity from each of the areas is recorded on magnetic tape from which it is graphically read out as a clearance curve. Considerable time and computation is necessary for the mathematical analysis of the temporal and spatial relationships between these multiple curves in order to determine whether a region of altered blood flow exists within the brain. Accuracy of these calculations is dependent upon adequate collimation and minimum overlap of adjacent regions.

The Ter-Pogossian scintillation camera, on the other hand, can visualize the whole hemisphere at all times; variations of the radioisotope tracer distribution are seen on the television monitor. These data are also permanently recorded on video tape for playback on Polaroid film as pictures of a single 1/30th of a second frame or of integrated frames for any specific time interval.

Initial studies with the camera were performed on three baboons to determine the parameters for the radioisotope dose and for the anatomical orientation (*2,3*). ^{99m}Tc-labeled albumin microaggregates (^{99m}TcAA), 1–8 microns in size, and ^{99m}Tc-pertechnetate, each in a high-specific-activity bolus, were injected into the internal carotid artery. In brief, visualization of the passage of these agents through the circulation is as follows: the area of the Circle of Willis in less than 0.1 sec, the insula in 0.2 sec, the jugular bulb in 3 sec and the superior sagittal sinus in 4 sec. The radioisotopes disappear from the venous circulation within 10–12 sec after injection.

The clinical application of the camera has been evaluated to date in 12 patients with intracranial lesions previously studied by carotid angiography and, in the majority of cases, by ^{99m}Tc-pertechnetate brain scan. The sequential order of administration of ^{133}Xe, ^{99m}TcAA and ^{99m}Tc-pertechnetate via an internal carotid catheter is based upon the agents' disappearance from the circulation. After one passage through the hemisphere ^{133}Xe is quickly removed by the lungs because of its equilibration with alveolar air. Similarly, ^{99m}TcAA is rapidly metabolized by the Kupffer cells of the liver. ^{99m}Tc-pertechnetate is given last because it maintains a relatively high blood level for several hours. To date, no untoward neurological sequelae have developed in the baboons or in the patients.

PROCEDURE

Following sterile percutaneous internal carotid artery placement of a Teflon catheter and completion of the angiographic studies, the patient remained in a supine, brow-up position with the lateral aspect of the cerebral hemisphere viewed through the fine collimator of the camera. Each of the 12 patients was given ^{133}Xe (10–13 mc in 1.7 ml), ^{99m}TcAA (6 mc in 0.3–0.5 ml) and/or ^{99m}Tc-pertechnetate (6 mc in 0.3–0.5 ml) in rapid (0.2–0.3 sec) injections. The passage of these test agents was monitored on the television screen and permanently recorded on video tape for 90 sec following each injection. The catheter was flushed with heparinized saline to prevent formation of thrombi and was removed within 10–15 min after starting the procedure. Polaroid pictures were reproduced from the video tape in 0.5-sec and 1-sec intervals (15 and 30 frames, respectively) for the 10 sec following the appearance of the test agent in the internal carotid artery; exposures were made every 10 sec thereafter for 90 sec or longer if indicated. By changing the camera aperture and suppressing background radioactivity, the relative concentrations of the test agent in the hemisphere could be ascertained.

RESULTS AND INTERPRETATIONS

The 12 patients studied have been grouped into 3 categories: brain tumors (a glioblastoma multiformi, a meningioma and a metastatic bronchogenic carcinoma), head trauma (four cases) and vascular disease (five cases).

Brain tumors. Only the results from the glioblastoma multiformi are given because similar results

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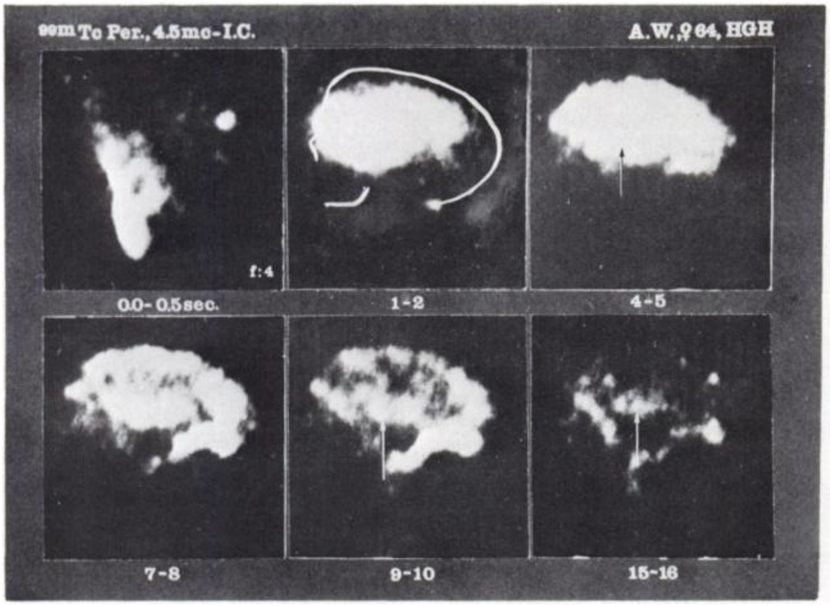

FIG. 1A. Patient A.W., female, 64 yr. Diagnosis: glioblastoma multiformi, left temporoparietal region. Internal carotid injection of 8 mc ^{99m}Tc-labeled albumin aggregates, 1–8 micron in size. Time intervals in seconds following injection are given below Polaroid photographs. Camera apertures: f4 and f5.6. The 0.0–0.5-sec picture shows electronicoptical image reversal effect (arrow) caused by the high specific activity bolus in carotid artery. Arrows indicate tumor site. See text.

were obtained in the other two tumors. ^{133}Xe, ^{99m}TcAA and ^{99m}Tc-pertechnetate each demonstrate radioactivity in the tumor area within 2 sec after injection; this uptake precedes the more generalized distribution of the test agent throughout the hemisphere. The immediate radiodensity in the tumor probably results from the diversion of the normal cerebral blood flow into the rich vascular bed of the tumor. The test agents, particularly the ^{99m}Tc agents (Figs. 1A and 1B), proceed to outline that portion of the hemisphere supplied by the internal carotid artery and subsequently visualize the superior sagittal and lateral sinuses. The radioactivity is concentrated and retained within the tumor area longer than within the adjacent brain; ^{133}Xe is retained in the tumor for more than 90 sec post-injection (Fig. 1C), ^{99m}TcAA for 15–16 sec and ^{99m}Tc-pertechnetate for 25 sec. This indicates delayed flow of the microaggregates through the tumor capillaries and probable extravascular diffusion of ^{133}Xe and ^{99m}Tc-pertechnetate. As seen in Fig. 1A, ^{99m}TcAA is visualized in the lateral sinus and the jugular bulb for 7–8 sec; this time is 4 sec longer than seen with normal venous drainage. The delay most likely results from venous compression secondary to increased intracranial pressure.

Head trauma. Two of the four head trauma cases had intracerebral hematomas which were suggested by carotid angiography and confirmed at operation. The other two patients had generalized cerebral edema. ^{133}Xe and ^{99m}Tc-pertechnetate demonstrated the intracerebral hematomas as regions of decreased

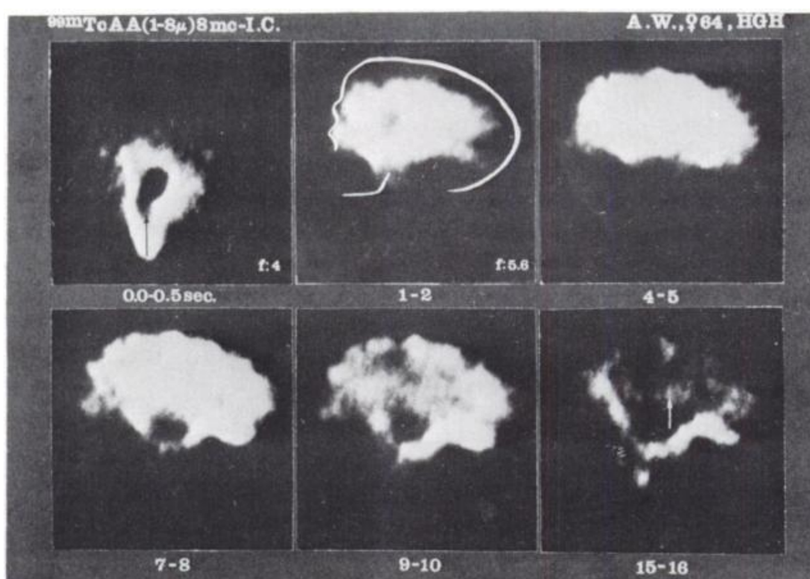

FIG. 1B. Patient A.W. (cont.). Injection of 4.5 mc ^{99m}Tc-pertechnetate. Note similarity to Fig. 1A. Significant residual radiodensity is seen in tumor in 15–16-sec picture (arrow).

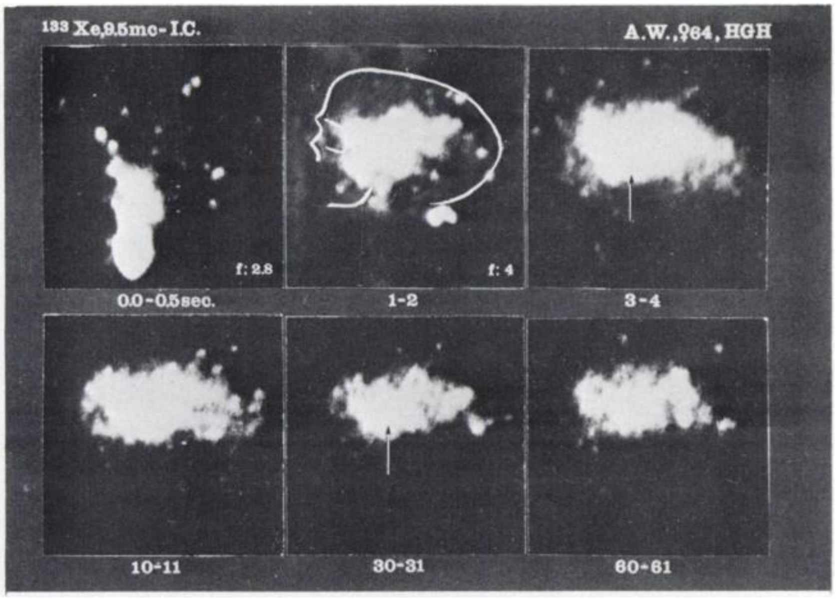

FIG. 1C. Patient A.W. (cont.). Injection of 9.5 mc ^{133}Xe. Note rapid appearance and delayed removal of ^{133}Xe in tumor region (arrows).

radiodensity compared to the radioactivity levels seen in the uninvolved brain. In the cerebral edema cases, the affected hemisphere showed markedly decreased radiodensity throughout the entire field. This may indicate destruction and/or poor blood perfusion through the microcirculation since ^{99m}TcAA also showed decreased radiodensity in these same regions.

Vascular disease. In this group, the results from ^{99m}TcAA and ^{99m}Tc-pertechnetate were similar and compared well with those obtained with ^{133}Xe. Two patients had angiographic evidence of arterial narrowing, and another had an occlusion of the middle cerebral artery. In the first two cases, ^{133}Xe showed a uniform decrease in radiodensity in the affected hemisphere. In the third patient, passage of ^{133}Xe was blocked in the region of the occluded artery; 20 sec later, however, radioactivity was visualized in the parietal area and probably represented collateral flow from the anterior cerebral artery. One arteriovenous malformation was studied. Tracer passage through the hemisphere containing the lesion was extremely rapid: the mass and the sagittal sinus were visualized within 2.5 sec, the jugular bulb in 3 sec and only a trace remained in the hemisphere in 10 sec. There was no evidence of significant radioisotope diffusion into the hemisphere. Normal test-agent appearance times were obtained from the studies on a patient with an aneurysm in the contralateral hemisphere. These times are: carotid artery to hemisphere delineation, 2–3 sec and to lateral sinus and jugular bulb, 3.5–4.5 sec. Only a faint remainder is visualized in 15–16 sec.

CONCLUSIONS

The Ter-Pogossian scintillation camera produces rapid sequential scintiphotographs of the passage of ^{133}Xe, ^{99m}TcAA and ^{99m}Tc-pertechnetate through the cerebral circulation. These preliminary results suggest that the camera studies can help distinguish on the basis of localized test-agent concentration, some brain tumors from intracerebral hematomas, which could not be clearly diagnosed by carotid angiography. They also permit assessment of the alterations in dynamic cerebral blood flow found in the vascular disease patients studied. Results are immediately apparent photographically but as yet they are not suitable for quantitative analysis.

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