Radioisotope (Gamma) Cerebral Angiography*

Technical Note

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D*Chiro in 1961 summarized the goals to be reached in the diagnosis of intracranial disease as follows: "The method or agent should indicate the presence, locate the site, and define the extension of the lesion. In addition, it should point to the nature of the lesion and at the same time entail minimal hazard and discomfort to the patient."

With the refinement of scintillation cameras and more specifically the Bender-Baird digital autofluoroscope,† these goals seem to be within reach. Instead of slowly scanning an area of nuclide distribution, scintillation cameras visualize the entire distribution at one time. Greater amounts of very short-lived nuclides can therefore be used which improve picture quality while maintaining a low radiation dose. Because of short exposure time and because the cameras are continuously sensitive to all areas within the field of view, rapid sequences of still pictures or time lapse motion pictures can be taken of subjects in which the distribution of radioactivity is changing. Thus the development of the autofluoroscope and the use of short-lived isotopes now make it possible to evaluate the cerebral arterial, capillary, and venous phases of circulation separately as well as to locate neoplasia and areas of vascular insufficiency or abnormality.

Not only does this technique make diagnostic goals attainable, but the method can be usefully applied to the objective evaluation of therapy.

Distal Autofluoroscope

The Detector. The detector assembly contains a mosaic of 294, sodium iodide crystals, 1½ inch thick, ½ inch square, and arranged in a 14×21 rectangular array, 6×9 inches in size. Each of the crystals is optically coupled to one photomultiplier tube, and 14 light pipes from any vertical row of crystals to another phototube. Pulses occurring simultaneously in one of the 14 horizontal positioning phototubes and in one of the 21 vertical positioning phototubes uniquely identify the crystal in which an interaction occurred. The direct-light piping system provides positioning information independent of pulse height and allows the use of wide spectrometer window widths with a resultant increase in detected count rate but without loss of positioning signal resolution. The use of direct light piping also increases resolution, as it permits the use of an automatic cross talk eliminator which rejects a count if signals are detected simultaneously in more than one crystal, thereby eliminating the recording of intercrystal Compton scatter.

Data Handling. A magnetic core memory permits storage of 1,000 counts per crystal location which then can be transferred to magnetic tape or for display on a cathode ray tube. In the normal display the light intensity of each segment is proportional to the accumulated events that occurred in the corresponding crystal, resulting in a pattern of various shades of gray. Self-normalizing circuitry can automatically set the highest count present at maximum brightness. All other counts are then scaled proportionately to the maximum. A background subtract control allows subtraction of up to 70% of full scale from all segments and the expansion of the remaining counts to a normalized maximum through the full dynamic range of the oscilloscope.

A memory flagging system has been devised which consists of a light-sensitive element which emits a signal when placed over a given resolution element on the oscilloscope display, and flags the corresponding memory core position. The accumulated counts within the flagged area can then be transferred to a strip chart recorder.
Preparation of Isotope. A useful radioisotope “cow” consists of a long-lived “parent” and a short-lived “daughter” which can be readily separated. The Cs$^{37}$ (30-year half-life) decays to Ba$^{137m}$ (2.6 min half-life). Blau, et al., have described the recipe for making the “cow”.$^{72}$

To “milk the cow,” one elutes the column with 2 cc of 0.1 N HCl, 0.1 N NH$_4$Cl, applying suction with a 10 cc syringe held open with a suitable spacer to avoid unnecessary radiation exposure during “milking.” In using the eluate from the “cow” for intracarotid injection, it must be neutralized and sterilized. By preloading the 10 cc eluting syringe with 1 cc of 0.2 N NaOH, one can neutralize the solution and bring it to isotonicity. It is then sterilized by passing the neutralized eluate through a 1-inch diameter 0.45 micron Millipore filter into another sterile plastic syringe. This step takes 15–20 seconds. Calibration is carried out with an ionization chamber. Milking can be repeated every 10 minutes.

The total body radiation dose is 0.5 mrad per millicurie administered. The Cs$^{37}$ content of the eluted Ba$^{137m}$ is not an important source of patient dose.

Procedure

The internal carotid artery was cannulated with a No. 18 spinal needle in 10 patients under local anesthesia. Six had a known diagnosis of glioblastoma multiforme, three had metastatic tumors, and one was normal. In each case injections of 10 mc of Ba$^{137m}$ were repeated at 10-minute intervals. No untoward reactions or significant patient distress occurred.

The digital autofluoroscope made counts at 1-second intervals and recorded the cumulative record of quantitative distribution on magnetic tape. This was continued as long as desired. The tape was then played back through the display system to determine whether further studies were required.

Results

The “normal” supply shows no tumor stain. In each tumor case the tumor was clearly identified and localized. Figures 1 to 4 are autofluorograms taken after the intracarotid injection of Ba$^{137m}$ in a typical tumor patient, a 75-year-old man with a known right parietal glioblastoma multiforme. A myocardial infarct caused his death 5 days after this procedure. A coronal section of the brain through the tumor mass is included in Fig. 3 for orientation.

The lateral view of the right hemisphere (Fig. 1) does not adequately define the tumor mass because the patient would not cooperate when turned to the side. However, the arterial and venous phases are well shown. At 8 seconds the venous drainage is well defined in both anteroposterior and lateral views. The various intracerebral vascular landmarks are labelled in the lower pictures in Fig. 2. These are more clearly identifiable by using the background subtract capacity of the machine. This permits visualization only.