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Brain Scanning with 200 Microcuries of ^{203}Hg Chlormerodrin

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INTRODUCTION

Concern over renal irradiation following brain scanning with ^{203}Hg chlormerodrin(1) has prompted the use of ^{197}Hg chlormerodrin (2) and ^{99m}Tc pertechnicate (3), both of short half life. The relative merit of these agents is the subject of controversy (4-13) but it is likely that the lower photon energy of ^{197}Hg detracts somewhat from its efficacy with deep lesions. It is also likely that tumor to brain concentration ratios are less favorable with technetium than with chlormerodrin. Because of such factors, but more because laboratories such as this one, which do modest numbers of brain scans, still find the routine use of short-lived isotopes an economic burden, ^{203}Hg still has widespread use.

In sparing the kidneys, an alternative to the use of short-lived agents is a smaller dose of ^{203}Hg. The usual dose of 10μC/kg employed with three-inch scanners (7-9, 14-17) was reduced to half or less by Avioli *et al* (18) who scanned quite slowly (18 cm per minute). For more than three years this laboratory has used high-efficiency collimators with thin septa in conjunction with a five-inch crystal. With one of these, the counting rate over a skull phantom is eight times that obtained with a widely used three-inch crystal and a 19 hole collimator. Good quality scans are obtained at 36 cm per minute after a dose of only 200μC of Mercury-203.

EQUIPMENT

A Model 1700 Nuclear Chicago isotope scanner was extensively modified (Fig. 1). It was fitted with a five-inch diameter by a two-inch thick crystal (Harshaw, 20MB8/B, Integral Line) shielded with 1.75" of lead all around. The complete probe with the collimator weighs 120 pounds and was mounted from beneath to extend through the movable housing of the scanner after the original probe height adjustment mechanism had been discarded.

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Several five-inch diameter focusing collimators were cast from lead with molds machined from aluminum. Of five collimators of different designs one two-inches thick with 91 holes seemed to give the best compromise between resolution and sensitivity for brain scanning. Depending upon their position in the pattern, the holes have diameters from 0.350″ to 0.365″ at the crystal face and from 0.232″ to 0.245″ on the under face. Each hole has a taper of 0.700″/ft. Septa have 0.063″ of lead between holes at all distances six inches from the geometric focus, which is four inches from the lower face of the collimator. Allen screws hold the collimator in the probe. The isoresponse curves of this collimator with ^{203}Hg in air are compared in Fig. 2 with those of two commercial collimators. The thinner septa and shorter holes give it less resolution but, greater sensitivity than the widely used collimators of commercially available instruments (Table 1).

Electronic components of the scanner were constructed to duplicate the circulits of the Picker, Model 2806-B scanner (vacuum tube), except that a Nuclear Chicago, Model 1810 radiation analyzer was substituted for the pulse discriminator module and a Nuclear Chicago, Model 183B scaler was used for the binary scaling circuit. The cathode ray tube (CRT) to produce the photographic image is RCA 1EP11. The light pipe to the film has a 0.125″ orifice.

An adjustable height table was built on the hydraulic base from a dental chair and fitted with a foam pad six inches thick. Restraining belts and a Picker Flexicast are used for immobilization.

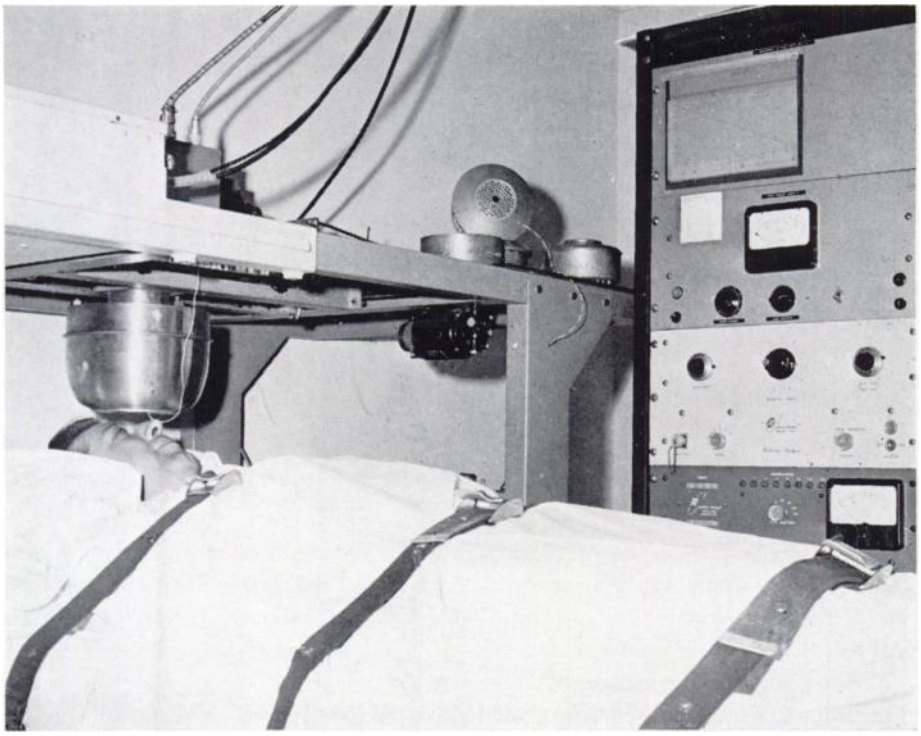

Fig. 1. Modified scanner and collimators. Electronic components separately mounted (see text).

METHOD

Each shipment of ^{203}Hg chlormerodrin (Squibb) is diluted with sterile saline to a concentration of 0.33 mc/ml. Doses (200μC) are given intravenously approximately one hour (see discussion) before the scan is begun.

After calibration of the analyzer the base level is set at 239 keV and the window at 80 keV. For a lateral view, the focus of the collimator is on the midline saggital plane of the head and for an anterior view the focus is set so that with the head on a pillow the collimator just clears the forehead. To obtain the maximum counting rate, the collimator light is spotted over the orbit in a lateral view and, on the bridge of the nose, in an anterior projection. The counting rate obtained with these conditions is from 2,000 to 6,000 cpm. With a two-second time constant on the rate meter, the CRT voltage is set (1000v) and the contrast enhancement (c/m range differential) adjusted to give the optimal CRT voltage drop (100v) between maximal and minimal areas of radiation. Minimal counting areas are usually temporal on lateral projections and 3 cm over either orbit on anterior views. The CRT light flash duration (density) is set to compensate for counting rate variations and the rate meter time constant is set at $\frac{1}{16}$ second before the scan is begun. The detector head moves at 36 cm per minute and scans six lines per inch. Each projection requires 20 to 25 minutes.

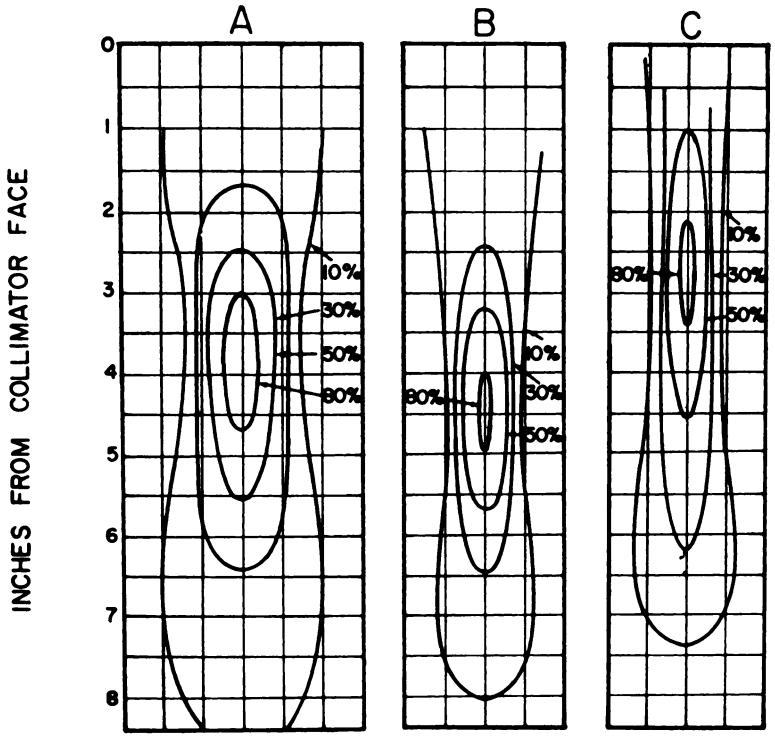

Fig. 2. Isoresponse curves of three collimators, a. 91 hole, 5″ diameter, 2″ deep, thin septa (see text), b. 85 hole, 5″ diameter, 3″ deep, thick septa (Picker #2111), c. 19 hole, 3″ diameter, 3″ deep, thick septa (Picker #2107).

RESULTS

Of 227 scans with this dose, 31 were unequivocally abnormal and of these 15 represented primary or metastatic tumors. The remaining positive scans were predominently of patients who had suffered cerebrovascular accidents. There were 20 scans with equivocal interpretations, mostly in patients with probable early metastatic tumors and with vascular accidents. The relatively low incidence of positive scans reflects the hospital practice of using the brain scan as a screening test. Virtually all cases of seizure disorders, vascular accidents, syncopal episodes, and malignancies with any central nervous system manifestations are scanned. In this series, there has been no instance of a tumor missed by scanning but diagnosed by other means. Because of the small number of lesions involved and the brief time that most of the negative cases have been observed, a detailed analysis of diagnostic efficiency would have little meaning.

Fig. 3 shows a normal scan and four scans that demonstrate proven lesions. Brief case summaries are included in the legend. It is of interest that the infarct (B) is clearly demonstrated from the opposite side. The scans merely demonstrate that unequivocal images are obtainable with low dosage.

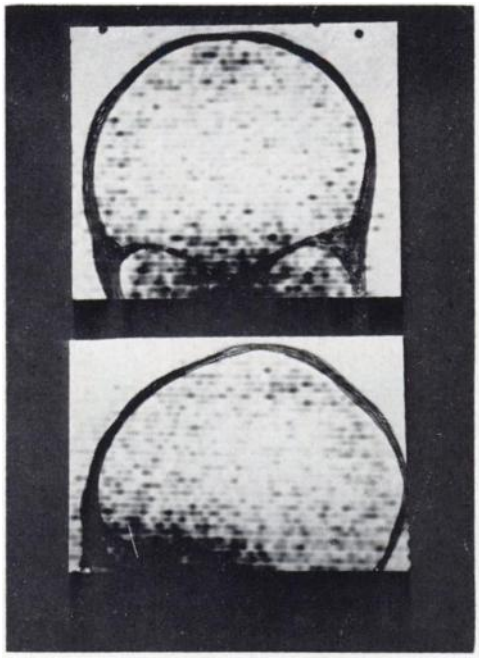

Fig. 3a. Normal scan. A 60-year-old male who developed signs of a mild cerebrovascular accident the day preceding this scan. Paresis of left arm and leg have subsequently improved.

DISCUSSION

Although these results do not quantitate the diagnostic accuracy of this procedure, the clarity of the images, the counting rates obtained, and the clinical correlation that has been possible all lead to the impression that the reliability of the technique equals that of conventional scanning methods with commercial equipment and a larger dose.

From the theoretical viewpoint, images will always improve with sharper collimation and the collection of more photons. It is possible that, at the present stage of brain scanning, the two factors are not optimally balanced in many instances. Perhaps, even with radiation as energetic as that of ^{203}Hg, collimators with three-inch long holes and thick septa lose more information by virtue of their lesser sensitivity than they gain by their superior resolving power. One would estimate from the isoresponse curves of Fig. 2 that the edge of a lesion would be diffused approximately 0.25 inches more with the collimator described here than with either of the two supplied with typical commercial scanners. This loss seems a small price to pay for a markedly enhanced sensitivity.

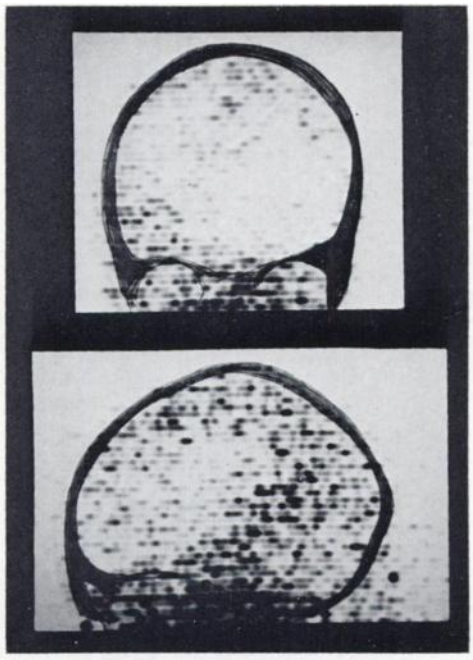

Fig. 3b. Cerebrovascular accident. A 69-year-old arteriosclerotic, hypertensive, male who suddenly developed weakness and numbness of the left side of the body 12 days prior to this scan. Has shown progressive improvement over a three-month period.

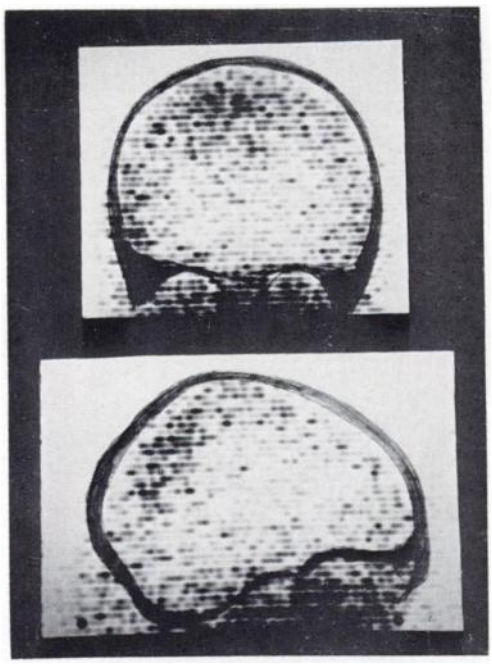

Fig. 3a. A scan of the liver using colloidal Au^{198} in a patient with post-necrotic cirrhosis to the scan followed by headaches and a cloudy sensorium. A meningotheliomatous meningioma in the position shown was removed six days following the scan.

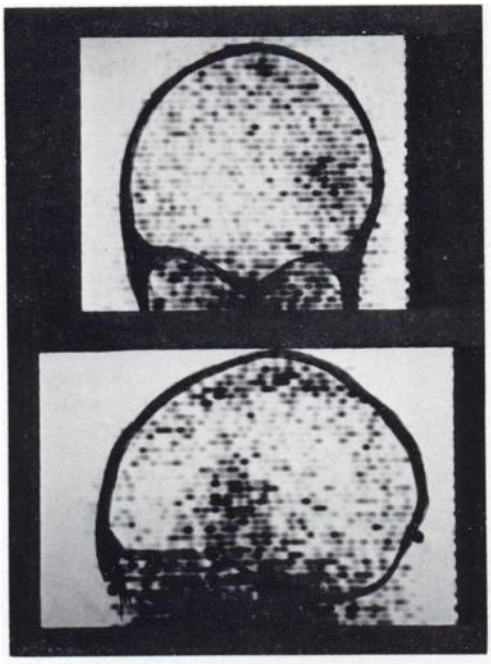

Fig. 3d. Glioblastoma. A 20-year-old male who developed focal seizures two months prior to this scan. Biopsy and partial removal revealed glioblastoma multiforme in the region shown. Deterioration has been rapid.

With liver, lung, kidney, spleen, and thyroid scans, where negative lesions are sought in a positive field, the lesser resolution of this collimator seems detrimental and collimators with heavier septa are used.

Experience with this dosage and earlier with higher doses (500μC, 100 scans; 350μC, 200 scans) indicates that when scanning is done two to four hours after injection the count rate is lower and images are poorer than when scans are performed between one and two hours post-injection. Although this variation from the experience of others (9, 14-17) is not explained, it could be related to predosing with untagged chlormerodrin, not done in this series because of its questionable value (19). Because of conflicting reports on the effect of predosing on renal retention (19-22) and the complete lack of information on its effect on brain and tumor pick-up, a comprehensive study is needed.

SUMMARY

With a five-inch diameter scintillation crystal and a two-inch thick 91 hole collimator with relatively thin septa, good quality brain scans are obtained after 200μC of ^{203}Hg chlormerodrin.

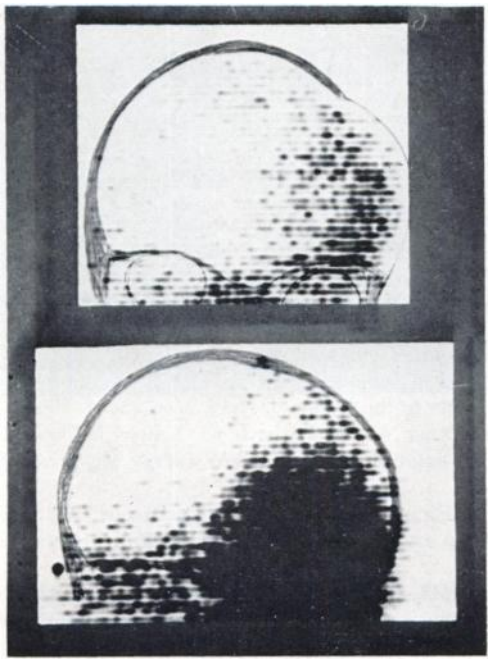

Fig. 3e. Glioblastoma. A 39-year-old male who had had a partial excision and irradiation of a cystic glioblastoma two years previously following a year of progressive memory loss and expressive aphasia. Autopsy nine days following the scan confirmed the identity and location of the tumor.

TABLE I

COUNTING EFFICIENCIES OF THREE DETECTOR-COLLIMATORS WITH A SKULL PHANTOM[1]

Detector System	*Max. Counting Rate*[2] *(c/m)*	*Simulated "Body"*[3] *Background (c/m)*	*Relative Efficiency*
5 × 2″ Crystal 91 hole collimator (see Text)	6850	450	8.0
5 × 2″ Crystal 85 hole collimator (Picker #2111)	1560	190	1.8
3 × 2″ Crystal 19 hole collimator (Picker #2107)	855	135	1.0

[1]Picker plastic phantom loaded with 0.25 and 0.13μC in 2 midline "tumors" and 15μc in main chamber.

[2]Corrected for background.

[3]A 200μC source of ^{203}Hg placed 6″ below and 18″ lateral to center of collimator face.

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