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WHOLE-BODY RETENTION OF ^{67}Ga-CITRATE

Evelyn E. Watson, Roger J. Cloutier, and William D. Gibbs

Oak Ridge Associated Universities, Oak Ridge, Tennessee

The retention of ^{67}Ga-citrate in patients with neoplastic diseases was measured with a whole-body counter which has a counting efficiency essentially independent of patient size and radionuclide distribution. From 2 to 5 mCi of ^{67}Ga-citrate were administered to each patient. Stable gallium constituted <3 μg/dose. The whole-body counting results were analyzed to determine whether differences in uptake and retention could be related to sex or age of the patients. Although there was great variation among patients, biological half-time of the ^{67}Ga was longer in the females than the half-time in the males. No significant differences could be shown to relate to the patients' ages.

Since 1968 the Oak Ridge Associated Universities (ORAU) Medical Division has been studying ^{67}Ga-citrate as a scanning agent for soft-tissue tumors. During this study whole-body counts were made of 112 patients who had received ^{67}Ga. We have used this counting data to estimate the biological retention of gallium citrate.

METHODS

Each patient was administered 2–5 mCi of ^{67}Ga-citrate. Chemical assays have shown stable gallium is a trace contaminant of <3 μg per administration. The amount of added citrate was reduced during the course of the study from 7 mg/kg to 1.0 mg/kg body weight and finally to 0.1 mg/kg; however, we were unable to detect differences in whole-body retention resulting from different citrate levels (*1*).

All of the patients had neoplastic diseases (Table 1) and were given ^{67}Ga to scan for soft-tissue tumors. As shown in Fig. 1, most of the 112 patients were over 40 years old, with the largest group in their 50's.

The ^{67}Ga retention was measured with the ORAU high-level whole-body counter (Fig. 2) (*2*). The 2 $\times$ 2-in. NaI(Tl) crystal was mounted about 9 ft directly above the bed where patients were counted in both supine and prone positions. The efficiency of the whole-body counting system was made essentially independent of nuclide distribution and patient size by using an "optimum counting window". This window was determined in a manner similar to that described by Gibbs, et al (*3*) and for our system includes that part of the ^{67}Ga spectrum between 50 and 330 keV. The system is capable of measuring body burdens of ^{67}Ga as low as 25 μCi.

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For reprints contact: Evelyn E. Watson, Medical Div., Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge, Tenn. 37830.

TABLE 1. PATIENTS' NEOPLASTIC DISEASES

Disease	Percent
Malignant lymphoma (Malignant lymphoma, Burkitt's type—4%)	34
Hodgkin's disease	27
Cancer of the lung	15
Cancer of the breast	5
Cancer of the thyroid	4
Cancer of the ovary	2
Chronic lymphocytic leukemia	2
Acute lymphocytic leukemia	1
Pseudolymphoma	1
Cancer of the vagina, acromegaly	1
Cancer of the testes	1
Cancer of the colon	1
Cancer of the rectum	1
Cancer of the kidney	1
Ewing's sarcoma	1
Histiocytoma	1
Osteogenic sarcoma	1
Metastatic neoplasm, primary unknown	1
	100

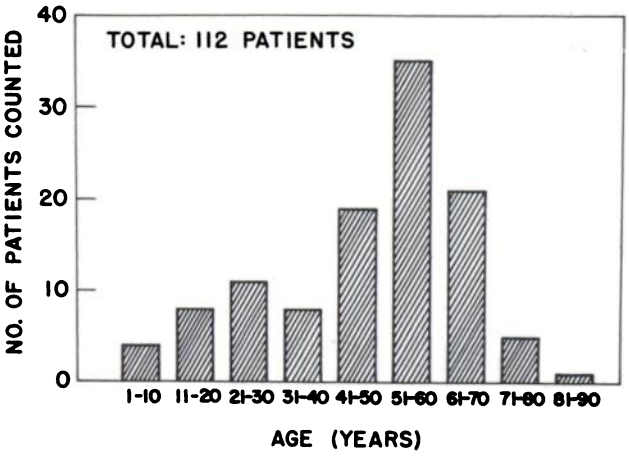

FIG. 1. Age distribution of patients included in study.

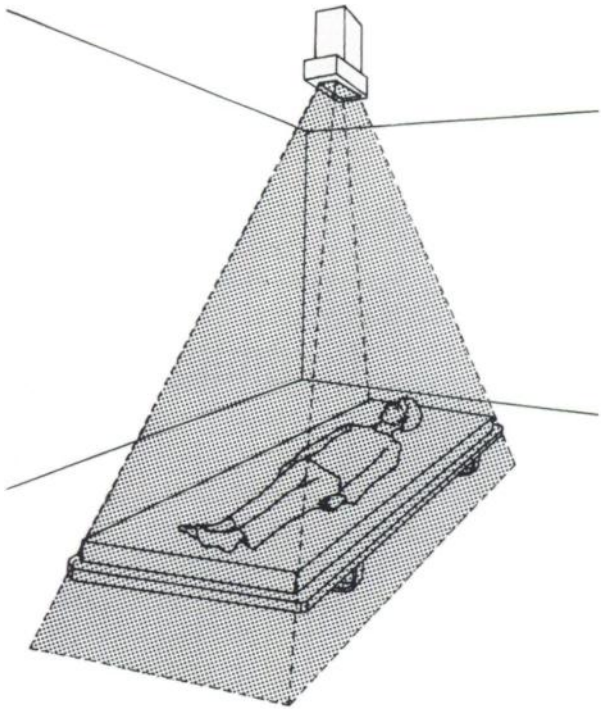

FIG. 2. ORAU high-level whole-body counter.

Whole-body measurements were made at intervals during the first 410 hr after the ^{67}Ga was administered. Some patients were counted daily for several days while others were counted only at 24 and 48 hr. All values were corrected for radioactive decay and represent biological retention of ^{67}Ga in the body when administered intravenously as ^{67}Ga-citrate.

RESULTS AND DISCUSSION

The average biological half-time of ^{67}Ga in the body was determined by fitting the whole-body counting data with a series of exponential curves. An exponential least-squares analysis revealed that a single exponential would not fit the data adequately. With a Digital Equipment Corporation PDP-11 computer we determined that the best statistical result in fitting the data to a single exponential function was obtained from the counts made 90 or more hours after administration of the gallium.

When we subtracted the long-lived component from individual data points, the resulting values varied greatly; however, when all counts were grouped into short time periods and the activity in the calculated long-lived component was subtracted from the average retention, the resulting values could be adequately fitted by an exponential least-squares analysis.

Figure 3 is a graph of the curves obtained by this method for all patients. Eighty-three percent of the administered ^{67}Ga has a half-time of 613 hr and a standard deviation of $\pm$83 hr. The short-lived component includes 17% of the administered ^{67}Ga and has a half-time of 30 hr. Because of the necessity of averaging the data, statistical evaluation of the short-lived component was not possible. Although a large percentage of the ^{67}Ga in the body may be present in tumor tissue, we have been unable to correlate differences in biological half-time with tumor mass.

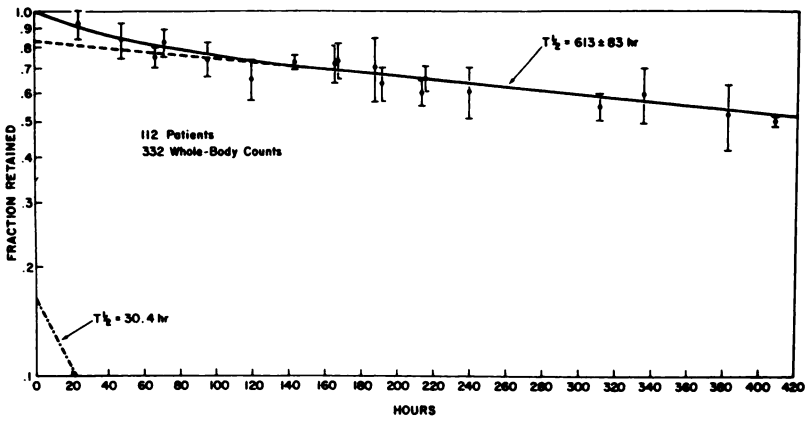

FIG. 3. Whole-body retention of ^{67}Ga-citrate in 112 patients.

TABLE 2. ^{67}Ga RETENTION: COMPARISON BY SEX

	No. of patients	Short-lived component		Long-lived component	
		Percent	T_b (hr)	Percent	T_b (hr)
All patients	112	17	30	83 ± 11	613 ± 83
Male patients	62	17	29	83 ± 12	502 ± 88
Female patients	50	18	35	82 ± 9	776 ± 156

TABLE 3. ^{67}Ga RETENTION: COMPARISON BY AGE

	No. of patients	Short-lived component		Long-lived component	
		Percent	T_b (hr)	Percent	T_b (hr)
All patients	112	17	30	83 ± 11	613 ± 83
Patients <40 yr	31	26	29	74 ± 6.8	607 ± 127
Patients >40 yr	81	13	28	87 ± 11	583 ± 81

To determine if differences in ^{67}Ga retention may be attributed to sex, we divided the counting results in this study according to the sex of the patients and analyzed the two sets of data by the same methods used for obtaining the retention values for all patients. Table 2 shows the results of our evaluation of the counting data from the 62 male patients. The short-lived component includes 17% of the administered ^{67}Ga and has a half-time of 29 hr; the long-lived component includes 83% and has a half-time of 502 ± 88 hr. Analysis of the whole-body counts of 50 female patients revealed an intercept of 18% in the short-lived component with a biological half-time of 35 hr (Table 2). The long-lived component includes 82% of the administered ^{67}Ga and has a half-time of 776 ± 156 hr.

The longer retention half-time for females differed by more than 1 s.d. from that for males, but an analysis of covariance was significant at only the 90% confidence level (F test). We believe additional data will show a more statistically significant difference in the ^{67}Ga retention between males and females.

A similar attempt to show a statistical difference in retention related to patient age was unsuccessful, perhaps because we lacked sufficient retention data for young patients (Fig. 1). Results of our comparison of patients over and under 40 are shown in Table 3.

From the 332 whole-body counts for 112 patients, we have calculated the biological retention of gallium intravenously administered as ^{67}Ga-citrate. The two-component curve which best fits the data is expressed by the following equation:

$$F(t) = 0.17e^{-\frac{0.693}{30}t} + 0.83e^{-\frac{0.693}{613}t} \quad (1)$$

where F(t) is a fraction of ^{67}Ga-citrate retained at t hours.

When the counting data were grouped according to the sex of the patient, we found that the long-lived component for males had a much shorter half-time (T_b = 502 hr) than for females (T_b = 776 hr). From the limited data available for young patients, we were unable to show differences in retention related to age. As additional data become available we plan to determine if other factors, such as patient's age, disease, and amount of tumor, influence ^{67}Ga retention.

ACKNOWLEDGMENT

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