mird / DOSE ESTIMATE REPORT NO. 2
SUMMARY OF CURRENT RADIATION DOSE ESTIMATES
TO HUMANS FROM ^{66}Ga-, ^{67}Ga-, ^{68}Ga-, AND ^{72}Ga-CITRATE

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SUMMARY OF ESTIMATED ABSORBED DOSE PER UNIT OF ADMINISTERED ACTIVITY FROM A SINGLE INTRAVENOUS ADMINISTRATION OF RADIOACTIVE GALLIUM CITRATE*

Tissue	Radioisotope of gallium (rads/mCi injected)			
	^{66}Ga	^{67}Ga	^{68}Ga	^{72}Ga
Gastrointestinal tract				
Stomach	0.52	0.22	0.042	0.65
Small intestine	1.4	0.36	0.21	1.4
Upper large intestine	3.5	0.56	0.23	3.0
Lower large intestine	3.6	0.90	0.094	3.7
Gonads				
Ovaries	0.64	0.28	0.048	0.84
Testes	0.54	0.24	0.039	0.74
Kidneys	1.1	0.41	0.089	1.2
Liver	1.2	0.46	0.096	1.3
Marrow	1.2	0.58	0.10	1.4
Skeleton†	1.1	0.44	0.094	1.2
Spleen	1.5	0.53	0.13	1.5
Total body‡	0.66	0.26	0.052	0.76

* All dose calculations assume a uniform distribution of activity in an organ. This was verified by gross autoradiography of the liver and spleen, but similar studies in kidney and bone showed a very nonuniform distribution (*1*).

† Skeleton = bone + marrow.

‡ Dose calculated assuming a uniform distribution of radioactivity in total body.

RADIOPHARMACEUTICAL

The radiopharmaceutical administered to obtain the biological data used in these dose estimates was ^{67}Ga-citrate (0.1–7 mg citrate/kg body weight). High-specific-activity ^{67}Ga (less than 3 μg stable gallium administered) was used in the total-body retention studies (*2*) and in 14 of the 23 patients in whom ^{67}Ga tissue concentrations were measured. Tissue concentrations were also measured in nine patients who received 0.2 mg of carrier Ga/kg body weight. No statistically significant difference in tissue concentration was seen in these two groups of patients except for bone, and this difference can be attributed to the samples studied rather than to a true carrier effect (*3*).

NUCLEAR DATA

Nuclear data on gallium are given in Table 1.

BIOLOGICAL DATA

The total-body retention of gallium is based on 332 total-body measurements of 112 patients during the first 480 hr after the administration of ^{67}Ga-citrate. The retention curve can be fitted with two exponential components (*2*). The long-lived component has a biological half-time of 613 ± 83 hr and an intercept corresponding to 83 ± 11% of the administered activity. The short-lived component has a biological half-time of approximately 30 hr and an intercept corresponding to approximately 17% of the administered activity. The standard de-

TABLE 1. NUCLEAR DATA*

Radionuclide	^{66}Ga (5)		^{67}Ga (†)		^{68}Ga (6)		^{72}Ga (7)	
Physical half-life	9.3 hr		78.0 hr		1.14 hr		14.1 hr	
Decay constant	0.07372 hr^{-1}		0.00885 hr^{-1}		0.6079 hr^{-1}		0.04915 hr^{-1}	
Mode of decay	Electron capture and beta-plus		Electron capture		Electron capture and beta-plus		Beta-minus	
Equilibrium dose constant for nonpenetrating radiation (gm-rad/μCi-hr)	2.1445		0.0873		1.5576		1.0764	
	E_i (MeV)	n_i	E_i (MeV)	n_i	E_i (MeV)	n_i	E_i (MeV)	n_i
Principal photons:	0.5110	1.167	0.0933	0.380	0.5110	1.760	0.6010	0.080
E_i, energy	0.8335	0.060	0.1845	0.239			0.6300	0.270
n_i, mean number/dis‡	1.0392	0.373	0.3002	0.161			0.8350	0.960
	2.1898	0.056	0.3936	0.043			0.8940	0.100
	2.7521	0.227					1.0500	0.070
							1.5980	0.050
							1.8600	0.050
							2.2010	0.260
							2.4900	0.070
							2.5080	0.140

* For complete compilation of nuclear data, reader is referred to references cited (*5,6,7*). Values computed by L. T. Dillman using method described in Ref. 8.

‡ Photons whose mean number per disintegration is 0.05 or greater.

† New decay information to appear in revised MIRD Pamphlet No. 6.

TABLE 2. CONCENTRATION OF ^{67}Ga IN VARIOUS TISSUES (3)*

Tissue	No. of patients	% administered activity/kg	
		Mean	Range
Spleen	20	4.1	0.4 –10.2
Kidney cortex†	12	3.8	0.7 – 8.4
Adrenal	16	3.8	0.6 –11.5
Marrow	16	3.6	0.7 – 9.9
Liver	19	2.8	0.6 – 5.2
Kidney†	16	2.7	0.6 – 6.2
Bone†	16	2.6	0.04– 9.2
Kidney medulla†	11	2.0	0.4 – 6.5

* Radioassay of autopsy tissue corrected for radioactive decay and normalized to a body weight of 70 kg.
† Autoradiograms demonstrate nonuniform distribution of activity (1).

viation for the short-lived component cannot be reliably estimated.

Table 2 gives the concentration of ^{67}Ga in various organs of 23 patients with malignant neoplasms who died from 3 hr to 22.7 days after ^{67}Ga-citrate was administered (*3*). Studies with a linear scanner demonstrated that after the first 24 hr there are minimal changes in the distribution of ^{67}Ga except in the gastrointestinal tract.

ABSORBED-DOSE ESTIMATES

The dose to the total body was calculated by using the basic MIRD dose equation and the total-body retention data. The dose to specific organs, except the bone marrow and gastrointestinal tract, was calculated by using Eq. 13 of Ref. *4* which takes into account the dose delivered by the nearby organs and the remainder of the body. The mean tissue concentrations in Table 2 were used as the initial tissue concentrations for the calculations. Seventeen percent of the activity in each organ was assumed to leave the organ with a biological half-time of 30 hr and the remaining activity with a half-time of 613 hr.

Since the average concentration of activity in bone is about the same as that in marrow, it is assumed that the loss of energy to bone by radiation emitted from the marrow is balanced by a gain of energy emitted from bone to marrow. Hence, the nonpenetrating radiation dose to the marrow was assumed to be equal to the average nonpenetrating dose to the skeleton (bone and marrow). The penetrating radiation dose to the marrow from activity in the bone end marrow was calculated by using the absorbed fraction for the skeleton irradiating the marrow because the absorbed fractions for marrow to marrow have not been calculated. The penetrating radiation dose to the marrow from activity in other organs was calculated in the standard manner since these absorbed fractions were available to the MIRD Committee. Retention of activity in the organs was as described earlier.

The dose to the gastrointestinal tract was calculated by assuming that the 9% of the activity found in the feces (*3*) had entered the bowel in the small intestine and that the residence time in the small intestine, upper large intestine, and the lower large intestine was 4, 13, and 24 hr, respectively. The total dose to the gastrointestinal tissue includes the dose from activity in the tissue of the tract, its contents, and the remainder of the body.

DISCUSSION

The dose estimates for high-specific activity radiogallium administered as gallium-citrate will be revised as additional total-body retention and tissue distribution data become available.

If additional data are available from your laboratory, please inform Edward M. Smith, Executive Director, MIRD, Society of Nuclear Medicine, P.O. Box 219, Perrine Branch, Miami, Fla. 33157.

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