PHYSICS

Dosimetry in Lymphoscintigraphy of Tc-99m Antimony Sulfide Colloid

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A quantitative kinetic technique using a scintillation camera has been developed for investigating lymph drainage and the uptake in the lymph nodes of $^{99m}TcSb_2S_3$ colloid injected subcutaneously. Twenty-two patients with primary malignant melanoma were examined. Lymph-node dissection was performed and 185 lymph nodes were individually measured for radioactivity. The kinetics of colloid uptake in individual nodes can be expressed by a simple two-compartment model. The outflow of colloid from the injection site was found to be monoexponential, and the tissue volume containing the injected colloid at the injection site increased asymptotically with time. A model has been developed for calculating absorbed doses at the injection site and in organs with colloid uptake. The following absorbed doses were estimated (μGy/MBq): whole body 0.7–4.5, gonads 0–22, liver 1.0–3.9, lymph nodes up to 1000 and injection site about 10,000. Possible biological effects in the skin and effective dose equivalents have been estimated when using other lymphoscintigraphic agents.

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There is considerable need for a method of examining the lymphatic drainage and lymph nodes in the diagnosis and treatment of malignant diseases. Although radiographic lymphography with contrast media is a clinically accepted method for investigating the lymphatic system (*1*), it is not always applicable because the contrast must be injected into a suitable lymph vessel. Moreover some clinical contraindications limit its use (*2,3*).

An attractive alternative method is lymphoscintigraphy, which is safe and simple and has a number of technical advantages (*4–6*). Several lymphoscintigraphic studies have been made both in animals and in humans using a Au-198 colloid or various Tc-99m-labeled colloids (*5–7*). The disadvantages of using a Au-198 colloid, despite its favorable particle size, are that the photon energy is rather high for scintillation-camera measurements and the high absorbed dose at the injection site, which may cause local tissue necrosis (*4*).

In a previous experimental study, it was shown that Tc-99m-antimony sulphide colloid (TcSbSC) has a particle size (3–30 nm) comparable with that of Au-198 colloid (5 nm), particles small enough to pass from the interstitial fluid into the lymphatic vessels (*8*).

These observations were applied to clinical practice by developing a quantitative scintillation-camera technique for the investigation of lymph drainage and the uptake of TcSbSC in the lymph nodes of patients with malignant melanoma (*9*).

The aim of the present investigation was to calculate, from the measured distribution of activity in patients, the absorbed doses in injection sites, individual lymph nodes, gonads, liver, and the whole body. In addition, dosimetric comparisons between different radiolabeled colloids and antibodies used in lymphoscintigraphy are given.

MATERIAL AND METHODS

Half a ml of TcSbSC with an activity of about 1 mCi (~40 MBq), was drawn into a syringe without addition of hyaluronidase or eqivalent drugs and injected subcutaneously. The preparations were tested for free pertechnetate with a gel-chromatography column-scanning technique (*8*). The labeling yield was regularly better than 95%.

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Twenty-two patients with primary malignant melanoma were studied. The colloid was injected subcutaneously around the scar after the primary diagnostic excision in 12 patients with melanoma of the trunk. In ten patients with melanoma of the lower extremities, the injection was made into the back of the foot. As a control, an identical injection was carried out at the same time on the contralateral side of the body.

Sequential images were taken with a scintillation camera every 30 sec during the first 1 or 2 hr over the inguinal, iliacal, and lower lumbar nodes on patients with melanoma of the lower extremities. Static images were taken on all patients 4–6 hr after injection.

The activity contents in tissues and organs were calculated from the count rate, C(t), in the region of interest after background subtraction. Using the known sensitivity factor, $\alpha(d)$, for the scintillation camera—i.e., the count rate per unit of activity for the actual depth, d, of the activity distribution center—the percentage uptake, P(t), can be calculated from

$$P(t) = \frac{C(t)}{\alpha(d) \cdot A(0)} \cdot e^{\lambda t} \cdot 100 \qquad (1)$$

where A(0) is the injected activity, λ the physical decay constant of Tc-99m, and t the time since injection (*6*).

The surgery was done on the day after the imaging. Lymph-node dissection of the nearest lymph-node station was made on patients with trunk melanoma, and ilioinguinal lymph-node dissection on patients with melanoma of the lower extremities. Each lymph node was weighed, inserted into a plastic tube, and measured for activity with an automatic sample-changing NaI(Tl) well counter.

The absorbed doses in injection sites, individual lymph nodes, gonads, whole body, and liver were calculated according to the ICRU and MIRD formulation (*10–12*). The gonadal and whole-body absorbed doses were also estimated using a computer program designed to calculate absorbed fractions in a human phantom (*13*). The dimensions of the human phantom followed the recommendations of the MIRD Committee (*14*).

The computer program was also used to calculate specific absorbed fractions in different parts of the phantom in order to estimate the effective dose equivalent.

RESULTS

The activities at 27 injection sites in 17 patients were measured in order to estimate the absorbed dose at the injection site. It was found that 80–100% of the injected colloid still remained at the injection site after 5 hr. The tissue volume containing the injected colloid increased asymptotically with time to reach 8–12 cm^3. The activity was uniformly distributed in the final activity volume.

The minimum and maximum activity uptake in organs and tissues, 5 hr after injection, were calculated from the stored image data and are given in Fig. 1.

In lymph nodes, the colloid uptake reached its maximum no later than 5 hr after the injection.

The activity contents in a total of 185 lymph nodes were measured on the day after injection, and the results are given in Table 1. The maximum uptake in a single

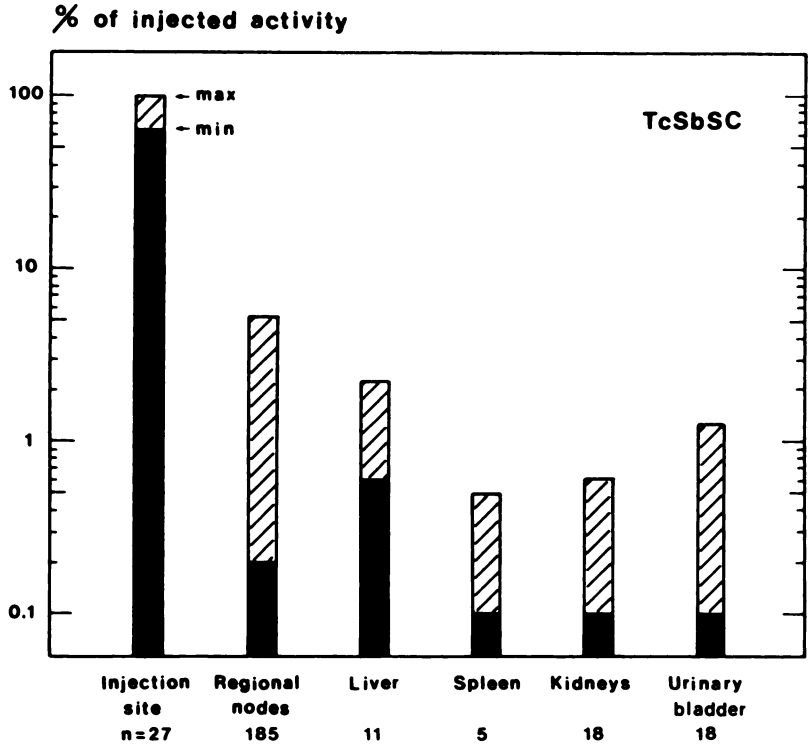

FIG. 1. Minimum and maximum percentage activity uptake in several tissues and organs 5 hr after a subcutaneous injection of TcSbSC.

TABLE 1. ACTIVITY DISTRIBUTION IN 185 LYMPH NODES MEASURED IN VITRO

% of injected activity	% of lymph nodes
<0.001*	30
0.001–0.01	30
0.01–0.1	28
0.1–1	12

* Limit of detectable activity.

lymph node was found to be 0.75% of injected activity (weight 0.5 g).

The mean weight of the lymph nodes was 0.7 ± 0.6 g (s.d.).

Absorbed doses when using TcSbSC. *Injection site.* Measurements at the injection site reveal that the tracer leaves the site with an approximately monoexponential outflow.

The time integral of the activity at the injection site, $\tilde{A}_v$, can then be expressed by

$$\tilde{A}_v = \int_0^\infty A(0)e^{-(k+\lambda)t}dt = \frac{A(0)}{k+\lambda} \qquad (2)$$

where A(0) is the injected activity, λ the physical decay constant of Tc-99m (0.115/hr) and k the rate constant of outflow, equal to $(1/t)\ln\{A(0)/A(t)\}$. The time integral will then be 6.2 A(0) with k = 0.045/hr and 8.7 A(0) if k= 0.

The mean absorbed dose in the final activity volume at the injection site, v, can be calculated from the formula

$$\bar{D}(v \leftarrow v(t)) = \frac{\tilde{A}_v}{m_v}\int_0^\infty \sum_i \Delta_i\phi_i(v \leftarrow v(t))\,dt \qquad (3)$$

where v(t) is the expanding activity volume, m_v the mass of the final activity volume, Δ_i the energy emitted per disintegration in the form of i-type radiation, and ϕ_i the absorbed fraction of the i-type radiation. The camera measurements indicate that the mean final activity volume is 10 cm^3. If the volume is 9 cm^3 after 5 hr, and taking the initial activity volume as v(0) = 0.5 cm^3, then

$$v(t) = 10 - 9.5\,e^{-0.45\cdot t}. \qquad (4)$$

Assuming an instant increase to the final volume (i.e., v(t) = v), Eq. 3 simplifies to

$$\bar{D}(v \leftrightarrow v) = \frac{\tilde{A}_v}{m_v}\sum_i \Delta_i\phi_i(v \leftrightarrow v). \qquad (5)$$

In Eq. 5 a constant value has been used for the absorbed fraction. This will underestimate the absorbed fraction in Eq. 3 by 10% for penetrating radiation where the increase in the activity volume is considered. This is a good approximation, however, because the nonpenetrating conversion electrons and Auger electrons from Tc-99m account for almost 85% of the absorbed dose. By taking the absorbed fraction for electrons as 1 in Eq. 5, thus ignoring (a) the small fraction absorbed inside the colloid particle (~0.5%), and (b) that outside the final activity volume (~0.5%), the absorbed dose will be very slightly underestimated. Values for Δ_i and, for photons, ϕ_i when the source is uniformly distributed in a unit-density sphere, are given by ICRU and MIRD (*10,15,16*).

The mean absorbed doses at the injection site for various final volumes are plotted in Fig. 2. The rapid decrease of the absorbed dose with increasing final volume shows that it is important to know the final volume when estimating the absorbed dose.

The final activity volume was usually about 10 cm^3, which gives a most probable mean absorbed dose of 30 rad/mCi Tc-99m (~8 mGy/MBq).

The maximum absorbed dose within the injection site can also be calculated. If there is no outflow, the absorbed dose in the initial activity volume can be calculated from the formula

$$D(v(0) \leftarrow v(t)) = \int_0^\infty \left\{\frac{A(0)e^{-\lambda t}}{v(t)\cdot\rho} \times \sum_i \Delta_i\phi_i(v(0) \leftarrow v(t))\right\} dt \qquad (6)$$

where ρ is the density of the volume. In this case, the maximum absorbed dose within the injection site will be about 150 rad/mCi Tc-99m (40 mGy/MBq).

Lymph Nodes. In order to estimate the absorbed dose in an individual lymph node, 90% of the injected colloid will be assumed to remain at the injection site after 5 hr. If k_1 is the rate constant for the flow of activity from the

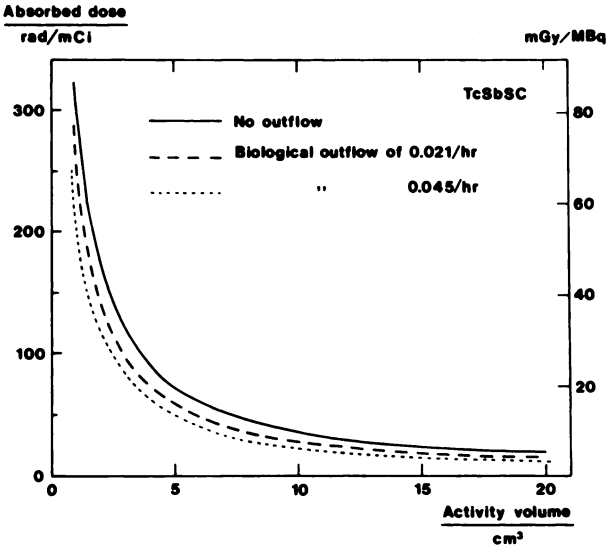

FIG. 2. Mean absorbed dose at injection site for different final activity volumes. Curves are given for injected activity of 27 μCi (1 MBq) Tc-99m and for three cases: when 80, 90, and 100% of the colloid remains at injection site after 5 hr.

TABLE 2. ABSORBED DOSE IN LYMPH NODES PER mCi ADMINISTERED Tc-99m

Lymph node weight (g)	Absorbed dose (rad/mCi) for given percentage activity uptake		
	0.01%	0.1%	1.0%
0.2	0.125	1.25	12.5
0.4	0.064	0.64	6.4
0.6	0.043	0.43	4.3
0.8	0.033	0.33	3.3
1.0	0.027	0.27	2.7
2.0	0.014	0.14	1.4
3.0	0.009	0.09	0.9

injection site to one lymph node, and k_2 the rate constant for the flow to other sites, then the total rate constant for the exponential flow from the injection site, $k_1 + k_2$, will be 0.021/hr. For a 0.1% uptake in a lymph node after 5 hr, k_1 will be one hundredth of $k_1 + k_2$, or 0.00021/hr.

The activity change during the first 5 hr in a lymph node can be described by the equation

$$\frac{d}{dt} A_{ln}(t) = k_1 A_{inj}(t) - \lambda A_{ln}(t) \qquad 0 \leqq t \leqq 5 \text{ h} \quad (7)$$

where

$$A_{inj}(t) = A(0)\, e^{-(k_1+k_2+\lambda)t} \quad (8)$$

Combining Eqs. 7 and 8 and integrating with respect to time will give

$$A_{ln}(t) = A(0) \frac{k_1}{k_1 + k_2} e^{-\lambda t} \{1 - e^{-(k_1+k_2)t}\} \qquad 0 \leqq t \leqq 5 \text{ h} \quad (9)$$

No further change of activity can be detected after 5 hr, as verified by the in vitro measurements of the excised lymph nodes. By inserting t = 5 hr in the parenthesis of Eq. 9 and the values of k_1 and k_2, the time integral of the activity in a lymph node can be expressed by

$$\tilde{A}_{ln} = \int_0^5 A_{ln}(t)dt + 0.001 \times \int_5^\infty A(0)\, e^{-\lambda t}dt = 0.0066\, A(0) \quad (10)$$

This value can be used in Eq. 5 to calculate the absorbed dose in a lymph node if m_v now denotes its mass.

The absorbed doses per unit administered activity in lymph nodes with different weights have been calculated, and the results are shown in Table 2.

We found the maximum uptake in a lymph node to be 0.75% (weight 0.5 g) giving an absorbed dose of 3.7 rad/mCi Tc-99m (~ 1 mGy/MBq).

Gonads. In order to estimate the absorbed dose in the gonads, we considered two theoretical cases in which the injection site is separated by 10 and 20 cm of tissue from the ovaries or testes. The absorbed doses in these two cases may be calculated from the formula

$$\bar{D}(r_1 \leftarrow r_2) = \tilde{A}_2 \cdot \Delta_{0.14}\phi_{0.14}(r_1 \leftarrow r_2), \quad (11)$$

where the equilibrium dose constant, $\Delta_{0.14}$, for 0.140-MeV photons is 0.2630 g rad/μCi/hr (0.07108 g Gy MBq/hr) (*16*); the time integral at the injection site

$$\tilde{A}_2 = \int_0^\infty A(0) \cdot e^{-\lambda t}dt = \frac{A(0)}{\lambda}; \quad (12)$$

and the specific absorbed fraction for 0.140 MeV photons is

$$\phi_{0.14} = \frac{1}{4\pi r^2}\left(\frac{\mu_{en}}{\rho}\right) \cdot B_{en}(\mu r) \cdot \exp\left\{-\left(\frac{\mu}{\rho}\right) \cdot (\rho r)\right\} \quad (13)$$

The mass energy absorption coefficient μ_{en}/ρ is equal to 0.0273 cm^2/g, the energy absorption buildup factor $B_{en}(\mu r)$ is equal to 6.5 for μr = 1.53 and 18.3 for μr = 3.06 mean free paths, and the linear mass attenuation coefficient μ/ρ is 0.153 cm^2/g (*11*).

The absorbed dose in the gonads will then be 70 mrad/mCi (19 μGy/MBq) for r = 10 cm, and 10 mrad/mCi Tc-99m (2.7 μGy/MBq) for r = 20 cm.

Under the same premises, the corresponding values from the computer calculations were (80 and 15 mrad/mCi) Tc-99m (22 and 4.1 μGy/MBq), respectively. In the above calculations we used the tabulated values for $B_{en(\mu r)}$ given by MIRD (*11*). This will overestimate the absorbed fractions by a few percent due to lack of

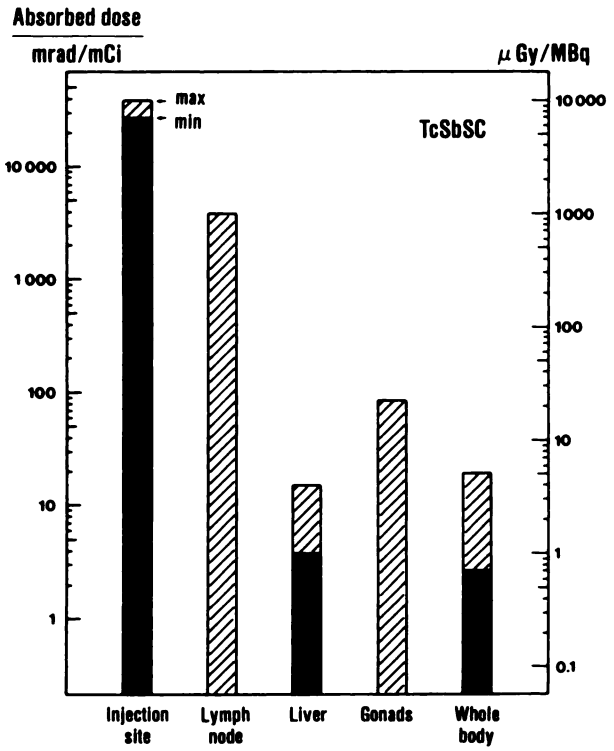

FIG. 3. Minimum and maximum expected absorbed doses in several tissues and organs when using TcSbSC.

backscattering material above the injection site (*10*). When injection is made on the foot, the absorbed dose due to the injection site will be about (0.004 mrad/mCi) Tc-99m (0.001 μGy/MBq).

Whole body. The "S" formulation given by MIRD (*12*) was used to get a rough estimate of the absorbed dose in the whole body. It was assumed that all the activity was distributed near the umbilicus. S values are given for the stomach contents as the source organ and the whole body as the target organ. Using this approximation, the S value for Tc-99m is 1.9×10^{-6} rad/μCi/hr (5.1×10^{-7} Gy/MBq/hr) (*17*). By multiplying this value by the time integral of the activity, the absorbed dose will be 16 mrad/mCi (4.5 μGy/MBq). This value will be an overestimate because the assumed center of activity is deeper than the subcutaneous injection site.

The computer program calculates the absorbed dose in the whole body on the assumption that the activity was injected either into the back of the foot or into the abdominal wall in the vicinity of the umbilicus. The absorbed dose in the former case was calculated to be 3 mrad/mCi Tc-99m (0.7 μGy/MBq) and in the latter case 15 mrad/mCi Tc-99m (3.9 μGy/MBq).

Liver. The time integral of the activity in the liver can be calculated by integrating Eq. 9 if k_1 now denotes the rate constant for the flow of activity from the injection site to the liver. This will give

$$\tilde{A}_{liv} = A(0)\frac{k_1}{\lambda(k_1 + k_2 + \lambda)}, \qquad (14)$$

or 0.135 A(0) with 1% colloid uptake in the liver after 5 hr ($k_1 + k_2 = 0.021$/hr and $k_1 = 0.0021$/hr).

The absorbed dose in the liver can now be estimated by using the "S" formulation. The absorbed dose per unit time integral, $S_{liv \leftarrow liv}$, is 4.6×10^{-5} rad/μCi/hr Tc-99m (1.2×10^{-5} Gy/MBq/hr) (*17*). Multiplying this value with the time integral the absorbed dose for 1% colloid uptake will give 6 mrad/mCi Tc-99m (1.7 μGy/MBq). With an uptake between 0.6 and 2.3%, the absorbed dose will be 4–14 mrad/mCi (1.0–3.9 μGy/MBq).

Estimated minimum and maximum values of the absorbed doses in the aforementioned tissues and organs are summarized in Fig. 3.

Comparative dosimetry for different lymphoscintigraphic agents. Other radiopharmaceuticals reported for lymphoscintigraphy are colloids labeled with In-111 (*18*), Hg-197 (*19*), and Au-198, which were extensively used earlier (*4,7*). In the past few years, interest has been focused on the possibility of using radiolabeled antibodies for lymphoscintigraphy. Reports have recently been published on subcutaneous injections of antibodies labeled with I-131 (*20,21*). Labeling of antibodies and antibody fragments with I-123 (*22*) and Tc-99m (*22,23*) have also been proposed.

Absorbed doses. Estimates have been made of the absorbed doses at the injection site and in individual lymph nodes after subcutaneous injections of these agents on the basis of the biokinetics of the TcSbSC. Two rate constants, 0 and 0.021/hr, have been used for the injection site, and a final activity volume of 10 cm^3 was assumed. For lymph nodes, estimates have been made for a weight of 1 g and a final uptake of 0.1%. The results are given in Table 3. These calculations can be considered as an upper limit because a greater clearance from the injection site can be expected for many of the agents. For I-131 anti-CEA, for example, animal experiments of our own indicate a rate constant around 0.08/hr.

Effective dose equivalent. In 1977 the International Commission on Radiological Protection (ICRP) recommended the use of the effective dose equivalent H_E (*24*), which can be used to estimate the total risk from irradiation in man. The effective dose equivalent is defined as the weighted sum of the average dose equivalent in some specific tissues and in the "rest of the body" according to the equation

$$H_E = \sum_i w(i) \cdot H(i), \qquad (15)$$

where w(i) is a weighting factor representing the proportion of the stochastic risk resulting from tissue (i) to the total risk, when the whole body is irradiated uni-

TABLE 3. ESTIMATED MEAN ABSORBED DOSES IN INJECTION SITE AND LYMPH NODES, BASED ON BIOKINETICS OF TcSbSC

Agent	Injection site k = 0 rad/mCi	Injection site k = 0.021/hr rad/mCi	Lymph node* rad/mCi
Tc-99m-Sb_2S_3 colloid	35	30	0.3
In-111 colloid	970	320	8
Hg-197-S colloid	1400	470	13
Au-198 colloid	6800	2280	65
I-131-labeled antibodies	12000	1750	110
I-123-labeled antibodies	130	90	1.1

* When the weight is 1 g and the final uptake 0.1%.

TABLE 4. TISSUES CONTRIBUTING SIGNIFICANTLY TO EFFECTIVE DOSE EQUIVALENT (H_E) AFTER INJECTION OF A RADIOLABELED COLLOID SUBCUTANEOUSLY NEAR THE UMBILICUS

		Tc-99m		In-111		Hg-197		Au-198	
Organ	w(i)	H(i) mrem/mCi	w(i)·H(i) mrem/mCi	H(i) mrem/mCi	w(i)·H(i) mrem/mCi	H(i) mrem/mCi	w(i)·H(i) mrem/mCi	H(i) mrem/mCi	w(i)·H(i) mrem/mCi
Gonads	0.25	52	13.0	600	150	130	32	520	130
Liver	0.06	16	1.0	1760	105	1370	82	5860	350
Spleen	0.06	27	1.6	3015	180	3000	180	13380	800
Kidneys	0.06	16	1.0	1760	105	1700	102	7790	470
Urinary bladder wall	0.06	52	3.1	780	45	315	19	1410	80
			—		—		—		—
Effective dose equivalent (mrem/mCi):			19.7		585		415		1830

formly. H(i) is the dose equivalent in a tissue of type (i).

The effective dose equivalent due to the injection site has been calculated for the different radiolabeled colloids by using specific absorbed fractions in five parts of the body (head, legs, and three parts of the trunk) given by the computer program. Calculations have been based on a subcutaneous injection near the umbilicus and a rate constant from the injection site of 0.021/hr. The uptakes of colloid after 5 hr in liver, spleen, and kidney are assumed to be 2, 0.5, and 0.5%, respectively. An approximation can be made that 0.5% of the activity in the urinary bladder is always present if the bladder is assumed to be emptied at regular intervals of five times a day, and if 1% of the total activity is assumed to be contained in the urine at the end of each interval. The results of these calculations are summarized in Table 4.

Cumulative radiation effect. Of particular interest is estimation of the possible biological effects of the radionuclides in the skin. A method of assessing and comparing biological effects of ionizing radiation is provided by calculating the Cumulative Radiation Effect (CRE), which is a concept often used in radiotherapy.

With fractionated radiation in radiotherapy, the skin tolerance dose is considered to be 60–70 Gy (6,000–7,000 rad) for 30 fractions during 6 wk (*25*), which is equivalent to a CRE value of 17–20 (*26*).

The expression for the CRE achieved under conditions of permanent implantation of a radionuclide in the skin is

$$R_c = nqr_0(z/\lambda)^z, \qquad (16)$$

where n (= 0.53) and z (= 0.71) are constants describing the equation representing the isoeffect curve of continuous radiation; q is the relative biological effectiveness (between 1.06 and 1.15 for the mentioned radionuclides); r_0 is the initial dose rate in Gy/day; and λ is the decay constant (*27*).

The CRE at the injection site, when 1 mCi (~40 MBq) of the radionuclides mentioned earlier is injected subcutaneously, was estimated from Eq. 16, and the results are given in Fig. 4. The final activity volume is assumed to be 10 cm^3 and calculations have been made for the rate constants 0 and 0.021/hr.

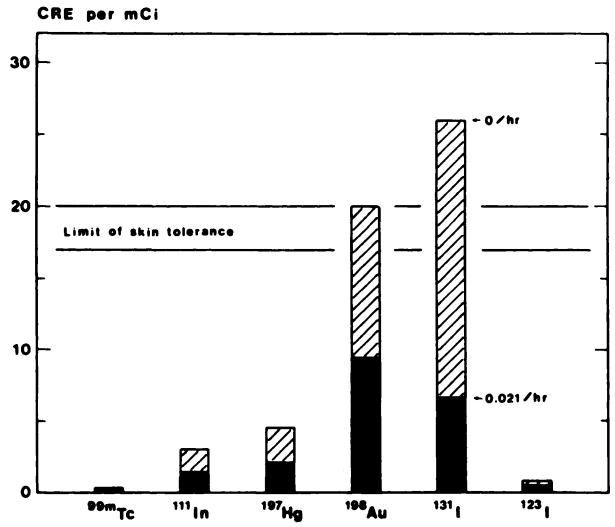

FIG. 4. CRE at injection site for 1 mCi (~40 MBq) of different radiolabeled agents, assuming final volume of 10 cm^3 and rate constants 0 and 0.021/hr.

DISCUSSION

The values in Fig. 3 give an indication of the sizes of the absorbed doses in some critical organs and tissues when the TcSbSC is injected subcutaneously.

Internal conversion electrons from Tc-99m (energy = 0.12 MeV) have an R_{90} value of about 0.15 mm [R_{90} is the radius of a sphere, centered on a point source in water, within which 90% of the emitted energy is absorbed (*10*)]. The absorbed fraction for electrons at the injection site will thus be close to unity. Since the electrons from Tc-99m account for about 85% of the absorbed dose in the final activity volume at the injection site, the shape of this volume will have little influence on the absorbed dose.

Table 3 clearly shows that Tc-99m- and I-123-labeled agents will give the lowest absorbed dose in the injection site and lymph nodes compared with other radiolabeled agents. Very high absorbed doses are received from

agents labeled with I-131 and Au-198, due mainly to the beta-minus decay of these radionuclides.

In Table 4, dose-equivalent and effective dose-equivalent values are given when different radiolabeled colloids are injected subcutaneously. ICRP recommends that nonstochastic effects will be prevented by applying a dose-equivalent limit of 50 rem (0.5 Sv) in a year to all tissues except the lens of the eye, for which the Commission recommends a limit of 30 rem (0.3 Sv) in a year. If 1 mCi (~40 MBq) is injected subcutaneously, Table 4 shows that this limit is never exceeded.

The lymph nodes have been omitted in Table 4 because, if weighted with the total mass of lymph tissue (about 700 g), their contribution to H_E will be very small. The skin's absorbed dose should not be included in H_E since it contributes only to nonstochastic effects (*24*).

Very high CRE values at the injection site are obtained for I-131 and Au-198 when all the activity remains at the injection site (Fig. 4). These values should be compared with the tolerance dose of the skin, which was found to be 17–20. Higher CRE values may result in desquamation and skin necrosis (*25*).

CONCLUSION

In this paper, the biokinetics and activity distributions of TcSbSC have been studied in patients with malignant melanoma. Based on these measurements, an extension has been made to other radiolabeled agents used in lymphoscintigraphy in order to make dosimetric comparisons.

The TcSbSC has been shown to give comparatively low values from calculations of CRE at the injection site as well as the absorbed doses and dose-equivalents in various tissues and organs. All values for this colloid are far below critical limits.

Special attention must, however, be given when using Au-198 and I-131, because these radionuclides may give very high absorbed doses.

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Greater New York Chapter
Society of Nuclear Medicine
Eighth Annual Scientific Meeting

September 10-12, 1982 **Sheraton Centre Hotel** **New York, New York**

Announcement and Call for Abstracts

The Eighth Annual Scientific Meeting of the Greater New York Chapter of the Society of Nuclear Medicine will be held Friday through Sunday, September 10-12, 1982 at the Sheraton Centre Hotel in New York City. Abstracts for the Scientific Program will be available to all registrants at the meeting. The program will be approved for credit toward the AMA Physicians Recognition Award under continuing Medical Education Category 1 through the Society of Nuclear Medicine and for VOICE credit for technologists.

For information concerning registration or commercial exhibits please contact:

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E. Meadow, NY 11554

Missouri Valley Chapter
Society of Nuclear Medicine
Annual Meeting

September 24-26, 1982 **Ramada Inn** **Columbia, Missouri**

The Missouri Valley Chapter of the Society of Nuclear Medicine will hold its Annual Meeting September 24-26, 1982 at the Ramada Inn in Columbia, Missouri.

Selected Topics in Radiopharmaceuticals will be the theme for this Annual Meeting, wherein specific radiopharmaceutical techniques and their clinical applications will be discussed by both a basic scientist and a physician.

For further information and registration, please contact:

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