Iodine-131 Contamination from Thyroid Cancer Patients

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High-dose radioactive iodine therapy using ^{131}I is the treatment of choice for patients with thyroid cancer following thyroidectomy. Because of the large amount of activity which is excreted during hospitalization, contamination hazard from ^{131}I excretion via perspiration, saliva, breath and urine may arise. In eight patients treated with doses of ^{131}I ranging from 3.7 to 14.8 GBq (100–400 mCi), activity levels were measured in room air, from room surfaces, the toilet, the patients' exhaled breath, skin, saliva and toothbrushes, and the gloves used by medical staff. Thyroid bioassays were also performed on medical staff personnel caring for these patients both before and two days after administration of the treatment dose. Removable activity from the skin was positively correlated with treatment dose and reached a maximum at 24 hr post-therapy. Removable activity from room surfaces exceeded the level of contamination which requires clean-up in a restricted area during the patient's hospitalization. Thyroid bioassays on medical staff showed no significant uptake 2 days after treatment. The relatively high activities present in the saliva, urine and on the skin of these patients emphasizes the need for all individuals coming in contact with these patients to be made aware of the contamination hazard present.

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High-dose radioactive iodine therapy using ^{131}I is the treatment of choice for patients with thyroid cancer following thyroidectomy. Because of the large amount of activity which is excreted during hospitalization, contamination hazard from ^{131}I excretion via perspiration, saliva, breath and urine may arise. While the patient is hospitalized, isolation procedures are followed to minimize the transfer of contamination to hospital personnel or visitors. In addition, after discharge the room and all objects which came in contact with these patients are monitored for contamination prior to release for general use. Upon discharge, it is required that patients be given instructions designed to minimize the transfer of radioactive material to persons living with or otherwise coming in contact with the patient (*4*).

A number of studies have measured the internal and external exposure of family members resulting from close contact with patients treated with ^{131}I for hyperthyroidism or thyroid carcinoma (*5–8*). Most of the patients involved in these studies were treated for hyperthyroidism with relatively low (less than 1.11 GBq, 30 mCi) doses of ^{131}I. There are few studies concerning the contamination potential associated with patients treated with high doses of ^{131}I (3.7 GBq, 100 mCi or higher) while they are hospitalized. Nishisawa et al. (*3*) reported on contamination from two patients hospitalized for eight days after being treated with 1.11 and 1.85 GBq of ^{131}I. Significant removable contamination was measured from eating utensils, clothing, bed linens and the patient's skin. They also measured and found significant activity in the patient's exhaled breath. Blum et al. (*9*) did not directly measure the activity exhaled by the patients treated for thyroid carcinoma with ^{131}I, but found significant airborne activities at the exit from the patients' rooms. Neither group, however, reported on removable contamination from room surfaces.

The purpose of our study was to determine the activity released by patients treated with therapeutic doses of radioiodine during hospitalization and the resulting levels of room and air contaminations.

MATERIALS AND METHODS

Eight patients with thyroid cancer treated with activities of ^{131}I ranging from 3.7–14.8 GBq volunteered to participate in this study. The ages ranged from 13 to 67 yr with a mean age of 47.7 yr. Five of the patients were women and three were men. Patients were hospitalized for about two days until the remaining activity was less than 1.11 GBq as required by federal regulations (*10*).

Alcohol pads were used to obtain samples of removable contamination from skin and room surfaces at 4, 24 and 48 hr. All wipe samples were taken from an area of about 2 cm × 5 cm and measured in Bq/cm^2. Skin wipe samples were taken from the forehead, neck, chest, forearm and palm. Wipe samples of the telephone receiver, tray stand, faucet, door handle and surface of the toilet bowl were obtained in order to determine room surface contamination.

Samples of saliva were obtained using cotton swabs at 4, 24 and 48 hr. The weight of each cotton swab was measured before and after the specimen was collected and the activity was deter-

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mined per gram of saliva. A new toothbrush was used by each patient upon arising in the morning and before retiring at night. Bristles were cut from the toothbrushes, weighed and sealed in a plastic bag and the activity per gram of bristle material was calculated.

Samples of the exhaled breath were obtained by having the patient breath into a plastic ventilator mask for 5 min. A vacuum pump attached to the mask through a plastic tube was used to draw air from the patient's exhaled breath through a charcoal filter mounted in the plastic tube. The trapping efficiency of the charcoal filter was determined by measuring the activities trapped in two charcoal filters placed in tandem in the plastic tube. It can be shown that the trapping efficiency is equal to one minus the ratio of the activity trapped in the second filter to that in the first filter. The trapping efficiencies of the charcoal filters used were 96% and measured activities were corrected for this trapping efficiency.

Mean room air concentrations of ^{131}I during 24-hr periods were determined by continuously drawing air at a known flow rate, about 1 liter/min, through a charcoal filter placed on the nightstand approximately 1.5 meters from the head of the bed.

All gloves used by medical staff caring for these patients were collected and counted.

All samples were counted using a gamma counter (Packard, Auto Gamma Spectrometer Model 3001) with the photo-peak centered at 364 keV. A 20% window was used for all measurements. The counting efficiency of the detector was determined using an ^{131}I source of known activity. Thyroid counts of medical staff caring for the patients were measured before and two days after administration of the therapy dose.

RESULTS

Mean removable skin activities from the forehead, chest, neck and hands of the subjects obtained at 4, 24 and 48 hr after treatment are shown in Figure 1. These graphs and those subsequently displayed are subdivided according to the dose of ^{131}I the patient received. There were three patients who received 3.7 GBq, three who received 7.4 GBq, one who received 11.1 GBq and one who received 14.8 GBq. Activities of the wipe samples range from less than 10 to over 250 Bq/cm^2 (0.3 to over 6.7 nCi). Wipe samples taken from the four different locations of the body all displayed a similar time activity pattern. It was observed that the removable skin activity usually peaked at about

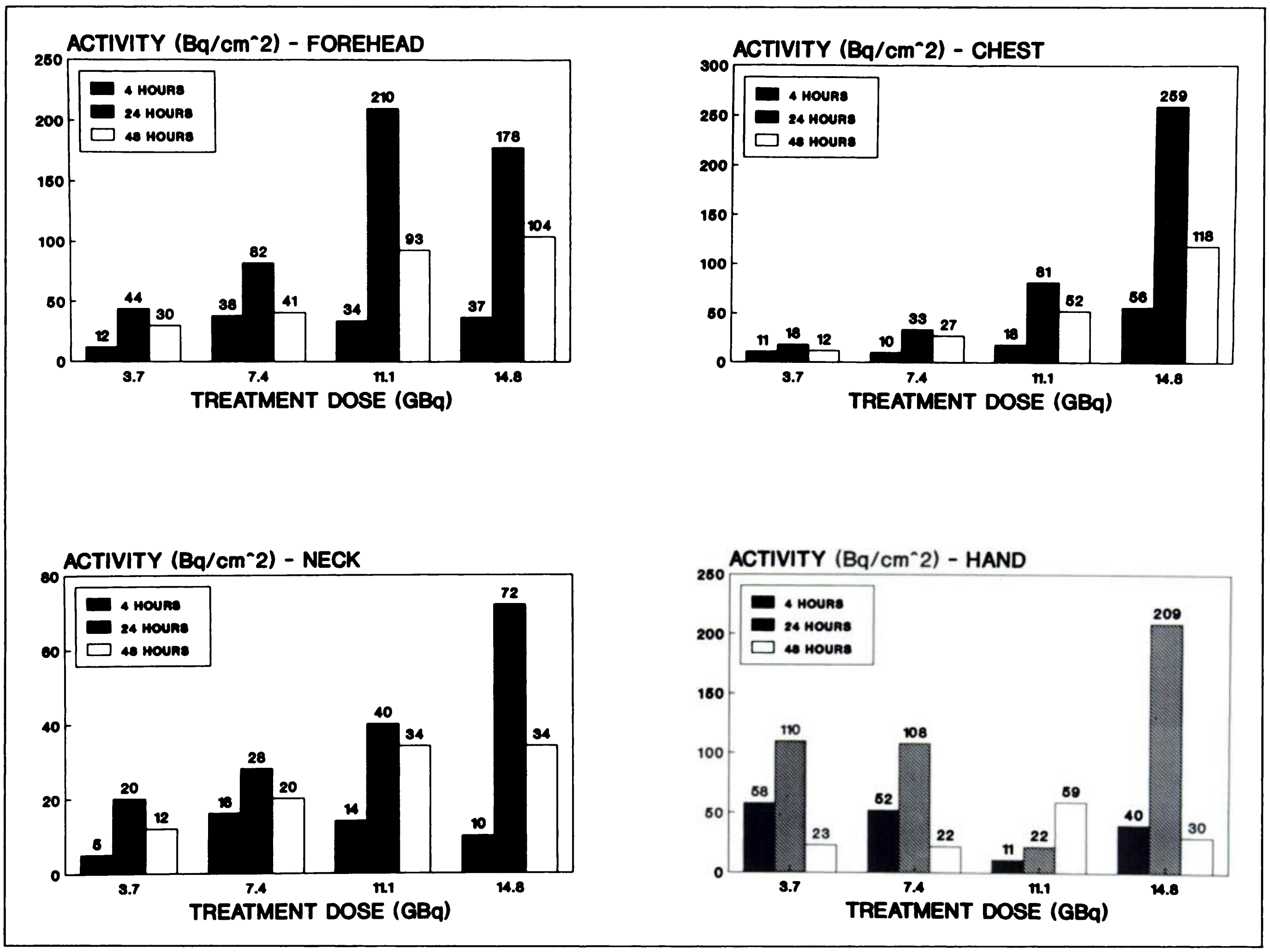

FIGURE 1. Removable ^{131}I activity from the forehead, chest, neck and hand versus time post-therapy for the different treatment doses.

24 hr post-therapy for all dose levels and decreased thereafter. The only exception was for the activity from the hands of the patient treated with 11.1 GBq. Removable skin activity increased with increasing treatment dose. The correlation coefficients between removable skin activity 24 hr post-therapy and treatment dose were 0.90 for the forehead, 0.91 for the chest, 0.88 for the neck and 0.26 for the hand. The correlation coefficients at 4 and 48 hr were also positive and of similar magnitudes. The low correlation coefficient noted for hand contamination is probably due to the significantly lower removable contamination in the patient treated with 11.1 GBq who washed her hands frequently during the evaluation period.

Mean activities of wipe samples taken from the telephone receiver, tray stand, bathroom door handle and the faucet of the wash basin are shown in Figure 2. Removable activities from these surfaces ranged from less than 1 to 190 Bq/cm^2. Generally, removable contamination increased with increasing treatment dose. However, the patient treated with 14.8 GBq had a very low telephone receiver contamination. This subject made few, if any, telephone calls during hospitalization. The activity from the tray stand was generally less than 20 Bq/cm^2 while that from the bathroom door handle was variable, but less than 20 Bq/cm^2 in all cases. Removable contamination from the faucet appeared to increase with increasing dose except for the patient treated with 11.1 GBq.

Removable surface activity from the rim of the toilet bowl ranged from 0.66 to 1.88 kBq for men and 8 to 26 Bq for women. The mean activities for both male and female patients were calculated without separating these groups according to treatment dose since there was no apparent dependence on dose in these patients (Fig. 3).

The activity in the saliva and on the toothbrush bristles showed a positive relationship with treatment dose and time. The activity levels ranged between 0.3 to 4.5 MBq/g for saliva and were about 200 times greater than those for the toothbrush bristles (Fig. 4). Patients at each treatment dose level showed similar time-activity patterns for both saliva and toothbrush activity with activities peaking the second day post-therapy and decreasing thereafter. The patient treated with 14.8 GBq showed extremely low ac-

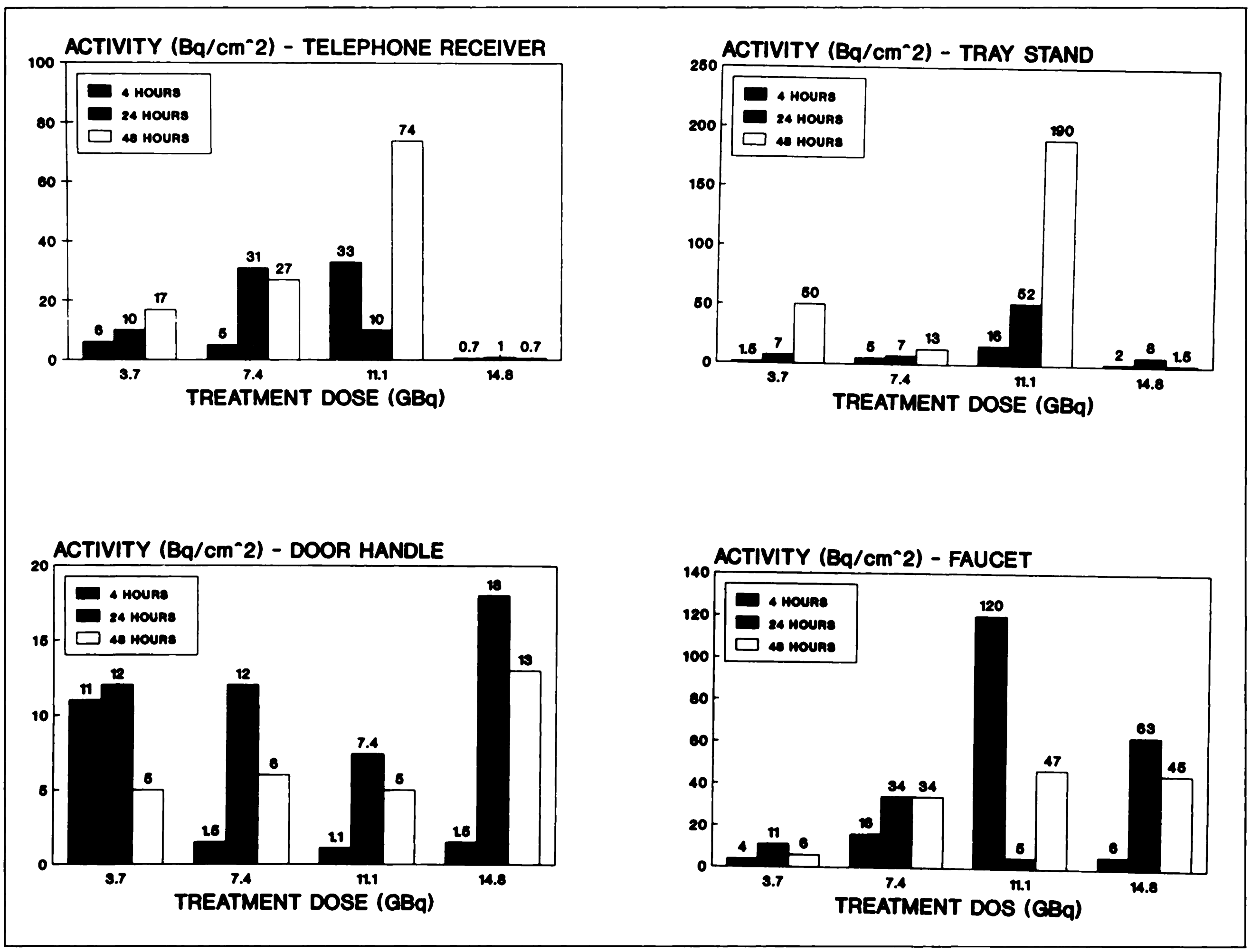

FIGURE 2. Removable ^{131}I activity from the telephone receiver, tray stand, door handle and faucet versus time post-therapy for the different treatment doses.

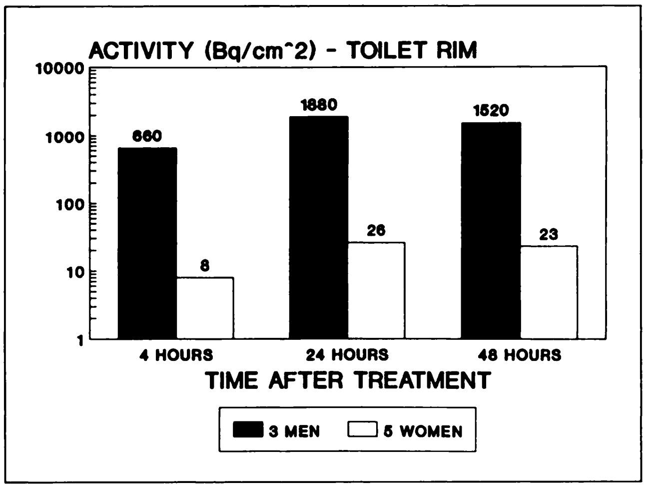

FIGURE 3. Mean removable ^{131}I activity from the toilet rim for male and female patients at 4, 24 and 48 hr post-therapy.

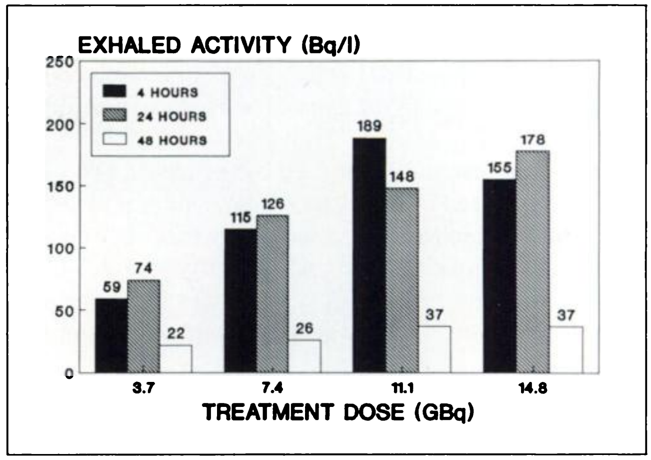

FIGURE 5. Exhaled ^{131}I activity versus time post-therapy for the different treatment doses.

tivity on the toothbrush in contrast to the others and this probably represents a difference in personal hygiene since the activity in the saliva of this patient was the highest of all patients 24 hr post-therapy.

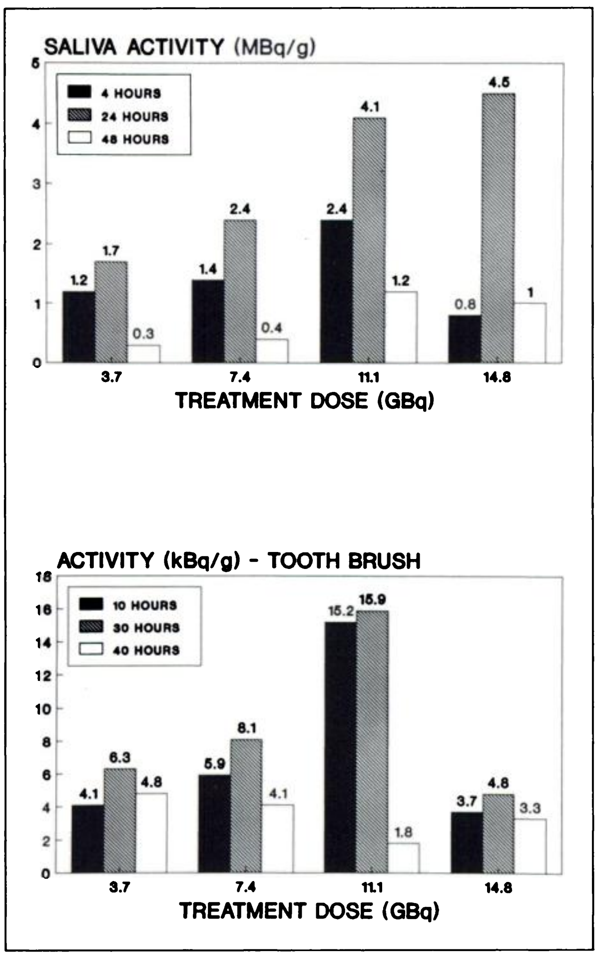

FIGURE 4. Iodine-131 activity per gram in saliva and on toothbrush bristles versus time post-therapy for the different treatment doses.

The activities exhaled in the breath ranged from about 20 to 190 Bq/liter and increased with increasing treatment dose (Fig. 5). The correlation coefficient between exhaled activity in the breath and treatment dose 24 hr post-therapy was 0.84. The mean ratio of ^{131}I activity in the exhaled air per hour to the treatment dose during the first day was about 1.5×10^{-6} Bq/hr per Bq of administered ^{131}I. Activity in the exhaled breath 48 hr post-therapy decreased to about 25% of that at 24 hr. Each treatment dose level showed similar time-activity patterns.

Mean room air concentrations of ^{131}I during the first day ranged from 0.08 to 0.44 Bq/liter. The mean air concentration of ^{131}I for Days 1 and 2 are shown in Figure 6. The same hospital room was used throughout this study and air flowing in and out of the room was measured to be 190 exchanges per day. For the patient treated with 14.8 GBq (Fig. 6), the air concentration of ^{131}I exceeded the maximum permissible concentration of 0.33 Bq/liter for a restricted area (*11*) during the first day post-therapy. Mean air concentrations were positively related to treat-

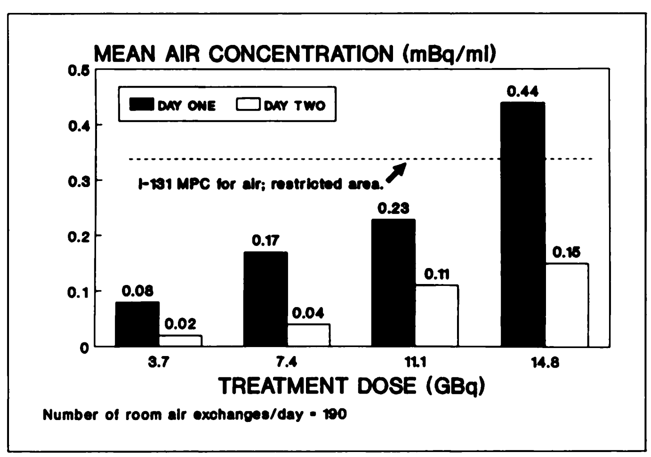

FIGURE 6. Mean air concentration of ^{131}I during Day 1 and Day 2 of hospitalization versus treatment doses.

ment dose on both Days 1 and 2 and there was a 50%–70% decrease in the mean air concentration between the first and second day. This drop in room air concentration parallels the decrease in the exhaled activity at 48 hr found in all subjects (Fig. 5).

The activity per glove pair used by the medical staff for routine care ranged from 100 to 560 Bq. One pair of gloves worn while administering tracheostomy care showed significant contamination reaching an activity of 3.7 kBq. Thyroid bioassays of medical staff did not show any significant uptake of ^{131}I at 2 days postadministration of the treatment dose.

DISCUSSION

Although exposure of a large number of people to a small amount of radioactive material could presumably increase the population at risk to develop cancer, there is no evidence currently to suggest that small amounts of radioactive contamination from individuals treated with ^{131}I for hyperthyroidism or for thyroid cancer represent a major public health problem. Studies of family members of such patients have found relatively low thyroid uptakes and external exposures. Patients treated for thyroid cancer with high doses of ^{131}I are required to be hospitalized until their radioactive content is less than 30 mCi (*10*). While hospitalized, these patients are not usually viewed as significant external radiation hazards to hospital staff, other patients or visitors (*12*). These patients excrete radioactive iodine in their perspiration, breath, saliva and urine and their hospital rooms are routinely contaminated to varying degrees. There is limited data (*3,9*) on the release of ^{131}I from patients treated with high doses for thyroid cancer. In this study, we documented the amount of radioactive material released by these patients during hospitalization and its transfer to the hospital room and air during hospitalization.

Removable skin activity appeared to reach a maximum 24 hr after treatment with this activity positively correlated to the activity of the treatment dose. Among the body areas, the hands and forehead showed the highest levels of removable contamination with the removable activity from the hands more or less constant at about 100 Bq/cm^2 after 24 hr. At most treatment doses, there appeared to be a decrease in removable activity from the skin by the end of the second day probably due to the decrease in blood concentration of ^{131}I. Removable activities from the different surfaces in the room were quite variable. The amount probably indicates the amount of contact each surface has with the patient's hands and saliva.

The current level of removable contamination in a restricted area at which clean-up is recommended is 2200 dpm/100 cm^2, while for an unrestricted area it is 220 dpm/100 cm^2 (*13*). Expressed in units used in this study this level is 0.36 Bq/cm^2. Removable activity from all skin surfaces and room surfaces exceeded this level for all patients throughout their hospitalizations. Although there was a decrease in removable skin activity post-therapy, the level at the time of discharge (48 hr) greatly exceeded the recommended level for unrestricted areas of 0.036 Bq/cm^2 and represents a source of potential contamination for the patients' home and office. At the time of discharge, the removable activity from all hospital room surfaces exceeded the level specified in the federal regulations (*14*) and required clean-up prior to use of the room by another patient.

The high level of removable activity from the patient's skin and room surfaces indicates that more attention may be needed to prevent contamination of room surfaces. The removable activity from the hands of the patient treated with 11.1 GBq was significantly lower than that of the other patients. This may be explained by this patient's constant hand washing. This suggests that encouraging patients to wash their hands and to shower frequently may be effective in reducing skin activity and its inevitable transfer to room surfaces. Since removable activity from the hands, forehead and other areas of the body are still high at the time of discharge, it is also our opinion that patients should be instructed to refrain from participating in cooking and food preparation for members of their family for some time after their discharge. While our study did not address the duration of this precaution, others have found measurable ^{131}I thyroid activity in family members of patients treated on an outpatient basis with ^{131}I and a period of several weeks seems appropriate.

Toilet rim contamination levels for the men were very high and about 70 times greater than for women. The high contamination probably results from the male practice of standing during urination. In our experience, floor contamination around the toilet is always higher with men than with women, and we routinely cover the floor around the toilet with absorbent paper drapes. The problem of high toilet rim and floor contamination may be reduced by instructing male patients to urinate while in a sitting position.

High activity levels of saliva were detected in all patients and there was a positive correlation with treatment dose. The high specific activity in the saliva (up to 5 MBq/g during the first day post-therapy), emphasizes the need to instruct nursing personnel who may come in contact with saliva or vomitus, in techniques to avoid contaminating themselves. Because of the high specific activity of the saliva at the time of discharge, we believe that it is necessary to instruct the patient to refrain from open-mouth kissing. This study, however, did not address the appropriate duration of this recommendation. We also feel that extra precautions are necessary for patients with cold or flu symptoms who's frequent sneezing and nose blowing can cause spread of radioactivity.

Residual activity on toothbrush bristles also increased with treatment dose except for the patient treated with 14.8 GBq. Bristle activities remained high at discharge, indicating that the patient's toothbrush should not be shared with others and that it be kept separate from the toothbrushes of other family members.

There is little published data on the activity in the exhaled breath of patients treated with high doses of ^{131}I, or the air concentrations in the hospital rooms of these patients. Nishisawa et al. (*3*) measured the activity in the exhaled breath of two patients treated with 1.85 GBq (50 mCi) and 1.11 GBq (30 mCi) of ^{131}I. Although these doses were similar, the initial exhaled activities differed by a factor of nearly 100. In our study, the activity in the exhaled breath was positively correlated to the administered dose ($r = 0.8$–0.9). We found the ratios of exhaled activity to the treatment dose for the first day to agree with those reported by Nishisawa et al. (*3*)

Activity in the breath increased during the first day and significantly decreased on the second day post-therapy. Taking the measured exhaled activities at 24 and 48 hr as representative of the activities exhaled during each day, and assuming the volume of air breathed per day to be 2.3×10^4 liter (*15*), the total activity exhaled into the air for the four treatment doses are 2.2, 3.5, 4.2 and 4.9 MBq, respectively. This is a relatively large amount of activity to be released into a confined area. For comparison in our institution, a spill or release of more than 3.7 MBq of ^{131}I is classified as a major spill which requires immediate attention. The mean concentration of ^{131}I in the air in the hospital room decreased 50%–70% by the second day compared to the first day at all treatment dose levels. For the patient treated with the highest activity, the mean ^{131}I air concentration exceeded the maximum permissible air concentration in a restricted area during the first day posttherapy. The hospital room used in this study underwent 190 air exchanges per day and it is likely that rooms with lower net air flow rates, the maximum will be exceeded at lower treatment doses. Blum et al. (*9*) measured the mean air concentration at 1 meter from a patient treated for thyroid cancer and found an air concentration similar to the air concentrations reported here, but no information on room air flow or the therapy dose was given. Since the maximum permissible concentration is defined as the uniform concentration not to be exceeded by a worker in any calendar quarter, it is unlikely that any nurse or other medical staff classified as a radiation worker will exceed the permissible quarterly dose. However, we believe that it is prudent to periodically measure the air flow rate of rooms used for patients treated with high doses of ^{131}I to insure that adequate air flow exists.

SUMMARY

In conclusion, we found significant levels of activity in the perspiration, saliva and breath of patients treated with ^{131}I for thyroid cancer during their hospitalizations. Removable activity from the skin and room surfaces exceeded acceptable levels of removable contamination for restricted areas during hospitalization and at time of discharge. These findings emphasize the importance of informing hospital personnel of the presence of significant levels of removable contamination and instructing them to follow procedures to prevent personal contamination when providing care for these patients. The relative high skin contamination and specific activity in the saliva found at the time of discharge also emphasizes the need for instructing patients in techniques to prevent significant transfer of radioactive iodine to members of their family and others after release from the hospital.

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