Radiation Safety Considerations for Post-Iodine-131 Thyroid Cancer Therapy

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The purpose of this study was to develop guidelines based on direct patient measurements as to when ^{131}I-treated thyroid cancer patients may resume close personal contact after release from the hospital. External exposure rates were measured on 27 patients using a calibrated ionization survey meter. The patients' exposure rates were measured at the time of release from the hospital and 2–7 days post-hospital discharge. Measurements were taken at 1, 0.6 and 0.3 meters from the patient's upright body axis (stomach to thyroid). Vertical movement of the survey instrument was utilized to obtain the maximum reading each time. All patients had exposure rates <2 mR/hr at 1 meter at 2–4 days post-hospital discharge. Eighty-eight percent (21/24) had exposure rates <2 mR/hr at 0.6 meter at 2–4 days post-hospital discharge. Guidelines can be prepared specifically for thyroid cancer therapy patients that are rational and consistent with existing radiologic health standards.

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Radioactive iodine therapy (^{131}I) is an integral part of functional thyroid carcinoma therapy in adults (*1*). For most thyroid cancer treatments, large doses of ^{131}I are administered to ablate residual thyroid tissue and functional metastases from thyroid cancer. The patient is hospitalized until the retained radioactivity is less than 1110 MBq (30 mCi) or the measured exposure rate from the patient is less than 5 mR/hr at one meter (*2*).

Radiation precautions are used to minimize the spread of contamination (from urine, saliva and perspiration) to hospital personnel, patients and visitors. The patient uses private sanitary facilities, eats using disposable table service and stores their linen for monitoring by trained radiation safety staff. The ^{131}I present in the patient also poses an external source of radiation exposure to others that is greatest immediately post-dose administration, and diminishes over the course of the hospital stay due to excretion and radioactive decay. External radiation exposure is minimized by adhering to current regulations that require a hospital stay in a private room until radiation levels are less than 5 mR/hr at one meter from the patient (or <1110 MBq {30 mCi} retained) (*2*). Visitors and nursing staff can minimize their radiation exposure by reducing the time spent in close proximity to the patient and by increasing their distance.

Various ways of quantitating the biologic behavior of ^{131}I sodium iodide in adult thyroid therapy patients and its effect on others in contact with the patient have been presented in the literature. Pharmacokinetic studies have reported the amount of radioiodine excreted in the urine, and the whole body retention of ^{131}I (*3*). External exposures to hospital personnel attending ^{131}I therapy patients have been calculated relative to dose, distance and time (*3*). Cumulative external exposures have been directly measured by film badge (*4*) and thermoluminescent dosimeters (TLDs) (*5,6*). Jacobson et al. reported that the external direct exposures (measured with TLDs) of family members of seven radioiodine therapy patients ranged from 0.06 to 22.2 mSv (6–2220 mrems) (*5*). The families of four patients treated for thyroid cancer were film-badged and the authors reported exposures from 0 to 0.8 mGy (0–80 mrads) (*4*). These studies represent a range of results relevant to hyperthyroid and thyroid cancer patients treated with ^{131}I.

Recently, we reported on guidelines specific to external exposure from hyperthyroid ^{131}I therapy patients based on direct measurement of exposure rate (*7*). Recommendations applicable to all ^{131}I therapy patients were published in the NCRP Report No. 37 in 1970 (*8*), by the Society of Nuclear Medicine (*9*) and others (*10*).

This study was undertaken to derive specific guidelines as to when ^{131}I-treated thyroid cancer patients may resume close contact with their children, spouses and co-workers following hospital discharge (FHD) based on their measured external exposure rates. External exposure rate less than 2 mR/hr was considered the acceptable criterion for resuming contact (*7*).

MATERIALS AND METHODS

Twenty-seven patients treated with ^{131}I for thyroid cancer were randomly selected to participate in this study. These patients consisted of 19 females and 8 males (age ranged from 21–69 yr

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with a mean value of 44.3). The therapy doses ranged from 4.62 to 8.14 GBq (125–220 mCi) of [^{131}I]sodium iodide; the mean dose was 5.85 GBq (158 mCi). All patients had a tracer 24-hr thyroid uptake measured and a neck and chest scan prior to treatment and whole body scans after therapy upon hospital discharge. Twenty-two of 27 patients had ^{131}I uptake only in their thyroid bed and/or neck. Five of 27 patients had additional extra-cervical localization of ^{131}I. The patients were restricted to radiation isolation in the hospital until the residual activity decreased to less than 1110 MBq (30 mCi) or the external exposure rate measured one meter from the patient was less than 5 mR/hr (*2*).

External exposure rates were directly measured at 1, 0.6 and 0.3 meters from each patient at the following time intervals which commenced upon the day of discharge from the hospital: Day 0–1, Day 2–4 and Day 5–7. Patients were asked to return for measurement at 2–4 days and 5–7 days following hospital discharge (FHD). Patients not measured at Day 0 returned the following day (Day 1) for measurement. Three of 27 patients and 21/27 patients failed to return for repeat measurements on Days 2–4 and 5–7, respectively. No attempt was made to call the "no show" patients.

At each time interval, exposure rates were measured with a calibrated ionization survey instrument at 1, 0.6 and 0.3 meter from the patient's upright body axis (stomach to thyroid). Vertical movement of the survey instrument at each distance was necessary to obtain the maximum reading at the various time intervals (*11*).

The ionization survey meter (Victoreen 470A, Cleveland, OH) was calibrated semi-annually on two points of each scale using a calibrated ^{137}Cs source traceable to the National Bureau of Standards (accuracy ±3%) (*12*). The energy response of the meter is 0.97 for ^{131}I and 0.96 for ^{137}Cs.

Fifty-nine patients treated with ^{131}I for hyperthyroidism who participated in our previous study (*7*) are included in this study for purposes of comparison. The hyperthyroid therapy doses ranged from 118 to 1106 MBq (3.2–29.9 mCi) of ^{131}I(NaI). The ages ranged from 27–83 yr with a mean range of 47.7. Forty-four patients were females and 15 were males. These patients had initial measurements taken within 20 min and at intervals of 2–4 days and 5–7 days post-dose administration (PDA) using the same technique described above.

Criteria for Restricting Contact

An external exposure rate less than 2 mR/hr was considered the acceptable criterion for resuming contact (*7*).

Statistical Analysis

The results are presented as mean ± standard error of the mean. Linear regressions were calculated by the least square's method. Statistical significance was determined by applying the Student's t-test. A p value < 0.05 was considered statistically significant.

RESULTS

No significant correlation between the uptake and administered dose was found in retrospect. No significant correlation between external exposure rates and either thyroid uptake or administered dose was found.

At approximately 40 hr PDA, the mean exposure rate was 5 mR/hr at one meter; the criteria used by the Nuclear Regulatory Commission for discharge of the patient (*2*).

TABLE 1
Measured External Exposure Rate (mR/hr)* Post-^{131}I Thyroid Cancer Therapy

	Days FHD		
Distance	0–1	2–4	5–7
1.0 m	4.0 ± 0.9 (27)	0.4 ± 0.4 (24)	0.4 ± 0.7 (6)
0.6 m	6.8 ± 2.7 (14)	1.0 ± 0.8 (24)	0.8 ± 1.4 (6)
0.3 m	15.7 ± 6.3 (14)	2.6 ± 2.2 (24)	1.7 ± 2.9 (6)

* Mean mR/hr ± s.d.
Numbers in parentheses are the number of patients.

Seven of 27 patients were discharged after one day in the hospital (Day 1), 18/27 patients were discharged on Day 2 and 2/27 patients were discharged on Day 3. Both patients (2/2) discharged on Day 3 had extra-cervical uptake of ^{131}I.

At the time of hospital discharge, the mean residual activity was 27.0 ± 6.3 mCi; the mean exposure rate measured at one meter was 4.0 ± 0.9 mR/hr (Table 1).

The exposure rates at 1 meter measured 0–1 days after the patients were discharged from the hospital are shown in Figure 1A. Exposure rates measured at 1 meter 2–4

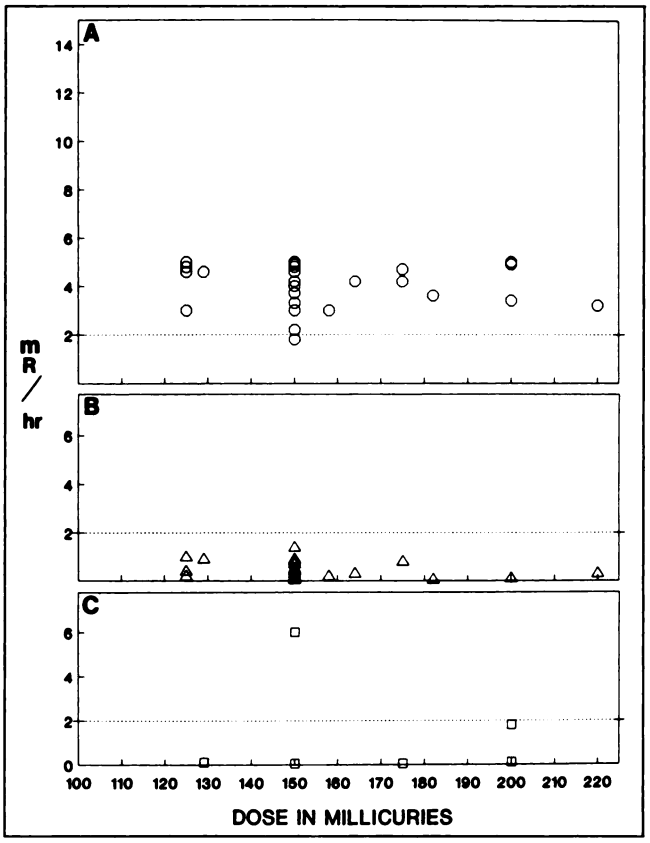

FIGURE 1. Exposure rate versus administered dose of ^{131}I at one meter from thyroid cancer patients. The criterion for restricting contact, 2 mR/hr, is represented by the dotted line. (A) 0–1 days FHD, circles. (B) 2–4 days FHD discharge, triangles. (C) 5–7 days post-hospital discharge, squares.

days later are shown in Figure 1B. All patients (24/24) had exposure rates <2 mR/hr at 1 meter 2–4 days FHD.

Patient exposure rates at 0.6 meter measured 0–1 days, 2–4 days and 5–7 days FHD are shown in Figure 2 (A, B, C, respectively). The mean exposure rate was 1.0 ± 0.8 mR/hr (range 0.07–2.9) at 2–4 days FHD. Eighty-eight percent (21/24) had exposure rates <2 mR/hr (Fig. 2B). The mean exposure rate was 0.8 ± 1.4 mR/hr (range 0.05–3.7) at 5–7 days FHD. Eighty-three percent (5/6) had exposure rates <2 mR/hr (Fig. 2C). The patient measuring 3.7 mR/hr had uptake of ^{131}I outside the thyroid bed (in the lungs) and was not discharged until 72 hr post therapy dose.

Patient exposure rates at 0.3 meter measured 0–1 days, 2–4 days and 5–7 days FHD are shown in Figure 3 (A, B, C, respectively). The mean exposure rate was 2.6 ± 2.2 mR/hr (range 0.2–8.0) at 2–4 days FHD. Fifty-eight percent (14/24) had exposure rates ≤2 mR/hr (Fig. 3B). The mean exposure rate was 1.7 ± 2.9 mR/hr (range 0.3–7.6) at 5–7 day FHD. Eighty-three percent (5/6) had exposure rates <2 mR/hr (Fig. 3C). The patient measuring 7.6 mR/hr had uptake of ^{131}I in the lungs.

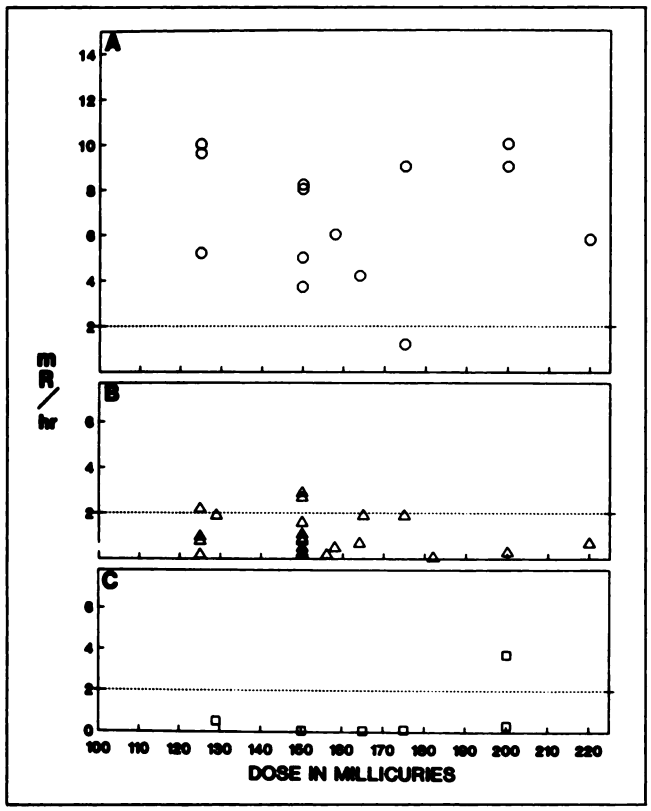

FIGURE 2. Exposure rate versus administered dose of ^{131}I at 0.6 meter from thyroid cancer patients. The criterion for restricting contact, 2 mR/hr, is represented by the dotted line. (A) 0–1 days FHD, circles. (B) 2–4 days FHD, triangles. (C) 5–7 days FHD, squares.

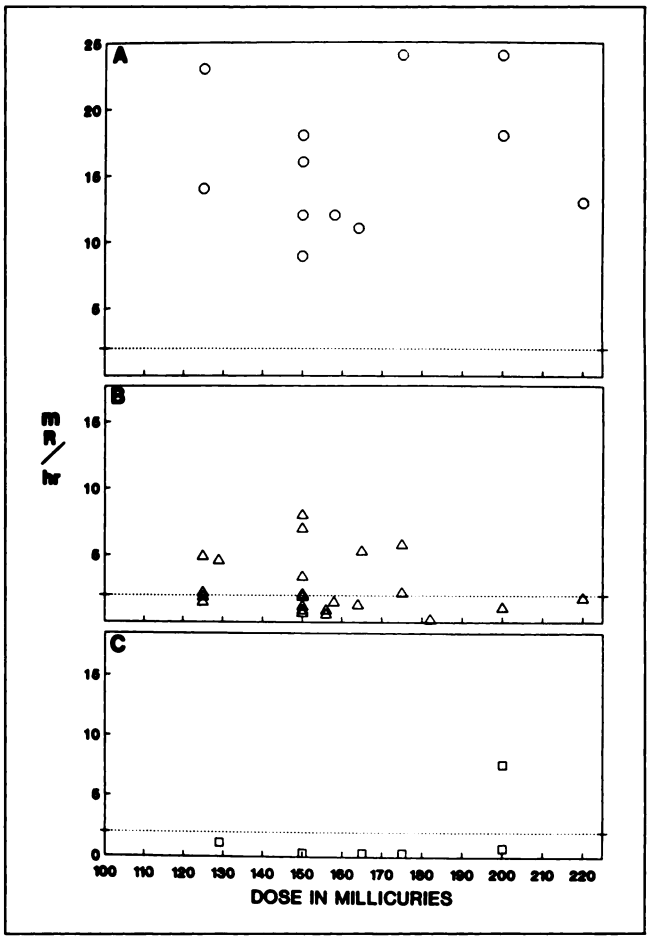

FIGURE 3. Exposure rate versus administered dose of ^{131}I at 0.3 meter from thyroid cancer patients. The criterion for restricting contact, 2 mR/hr, is represented by the dotted line. (A) 0–1 days FHD, circles. (B) 2–4 days FHD, triangles. (C) 5–7 days FHD, squares.

DISCUSSION

There is no evidence suggesting that the residual radiation present in ^{131}I thyroid cancer therapy patients (following release from the hospital) causes health problems in others. The NCRP, however, recommends that family members of a radioactive patient receive less than 0.5 rem in any one year and that fertile women with respect to the fetus receive less than 0.5 rem in the gestation period (*8*). Prolonged close contact with ^{131}I-treated patients can result in exposures to family members in excess of 500 millirems (*5*). The mean exposure rates of thyroid cancer patients measured at 0.3 meters PHD were 15.7 mR/hr at days 0–1, 2.6 mR/hr at days 2–4, and 1.7 mR/hr at days 5–7. A person continuously exposed (24 hr/day for 7 days) at 0.3 meter would receive a calculated dose of 1.1 rems.

Guidelines for when patients treated with ^{131}I for thyroid cancer may resume contact to within 1 meter, 0.6 meters and 0.3 meters are shown in Table 2. The criterion for removing restrictions is when the average exposure rate measures 2 mR/hr at that distance. A person would have to be continuously exposed to 2 mrem/hr for over 10 days

TABLE 2
Suggested Guidelines for Resuming Close Contact Post-^{131}I Therapy for Thyroid Cancer

Days FHD	0.3 m	0.6 m	1 m
0–1	Restrict amount of time	Restrict amount of time	Restrict amount of time
2–4	Some restrictions for contact with small children and pregnant women	No restrictions	No restrictions
5–7	No restrictions	No restrictions	No restrictions

to accumulate a dose of 500 mrem. Average exposure rates between 2 mR/hr and 3 mR/hr were considered borderline when applied to estimation of adult radiation risks. The groups of people at greatest risk from external radiation exposure are embryos, fetuses and children (*13,14*).

When this set of data were compared to the data previously published on ^{131}I hyperthyroid therapy patients (*7*), some statistically significant results are noted. At 2–4 days after release from the hospital, the mean exposure rates of patients treated for thyroid cancer are significantly less than the hyperthyroid therapy patients at both 0.6 and 0.3 meter ($p < 0.001$) (*7*). At 5–7 days, the mean exposure rates of patients treated for thyroid cancer are significantly less than the hyperthyroid therapy patients at 0.3 meters (<0.01). At 5–7 days FHD, the mean exposure rate of thyroid cancer patients was less than 2 mR/hr at 0.3 meter, whereas the mean exposure rate of hyperthyroid therapy patients continued to exceed 2 mR/hr at 0.3 meters for 8–11 days PDA (*7*). Patients treated with ^{131}I for thyroid cancer excrete the radioiodine more rapidly than the hyperthyroid therapy patients and are able to resume intimate close contact sooner after therapy than the hyperthyroid patients. Radiation precautions may be removed for most ^{131}I thyroid cancer therapy patients 2–4 days after release from the hospital.

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REFERENCES

1. Freitas JE, Gross MD, Ripley S, Shapiro B. Radionuclide diagnosis and therapy of thyroid cancer; Current status report. *Semin Nucl Med* 1985;15:122–125.
2. Title 10, Chapter 1, Code of Federal Regulation—Energy, Part 35, Section 35.75, October 31, 1986.
3. Castronovo FP, Beh RA, Veilleux NM. Dosimetric considerations while attending hospitalized I-131 therapy patients. *J Nucl Med Technol* 1982;10:157–160.
4. Harbert JC, Wells SN. Radiation exposure to the family of radioactive patients. *J Nucl Med* 1974;15:887–888.
5. Jacobson AP, Plato PA, Toeroek D. Contamination of the home environment by patients treated with iodine-131: initial results. *Am J Public Health* 1978;68:225–230.
6. Buchan RT, Brindle JM. Radioiodine therapy to out-patients—the radiation hazard. *Br J Radiol* 1971;44:973–975.
7. Culver CM, Dworkin HJ. Radiation safety considerations for post I-131 hyperthyroid therapy. *J Nucl Med* 1991;32:169–173.
8. NCRP, Precautions in the management of patients who have received therapeutic amounts of radionuclides. National Council on Radiation Protection and Measurements, Washington DC, Report No. 37, 1 October 1970;20.
9. Becker DV, Siegel BA. Guidelines for patients receiving radioiodine treatment. New York, The Society of Nuclear Medicine, Inc., 1983:5–6.
10. Hamburger JI. *The thyroid gland: a book for thyroid patients,* 3rd edition. West Bloomfield, MI. Joel I. Hamburger, 1985;51.
11. Thomas SR, Maxon HR, Fritz KM, Kereiakes JG, Connell WD. A comparison of methods for assessing patient body burden following I-131 therapy for thyroid cancer. *Radiology* 1980;137:839–842.
12. Noz ME, Maguire GQ. *Radiation protection in the radiologic and health sciences,* 2nd edition. Philadelphia; Lea & Febiger; 1985:82–85.
13. NCRP. Protection in Nuclear Medicine and Ultrasound Diagnostic Procedures in Children, National Council on Radiation Protection and Measurements, Washington, DC, Report No. 73, 1983:2.
14. Committee on Biological Effects of Ionizing Radiation, National Research Council (BEIR). The Effects on Population of Exposure to Low Levels of Ionizing Radiation. Washington, DC, National Academy Press; 1980.