THYROID
Volume 22, Number 1, 2012

DOI: 10.1089/thy.2010.0406

Thyroid Cancer Patients Treated with ^{131}I: Radiation Dose to Relatives After Discharge from the Hospital

Hervé Rémy,[1] Jérémy Coulot,[2] Isabelle Borget,[3] Marcel Ricard,[2] Nadine Guilabert,[4] Frédéric Lavielle,[2] Eve Camps,[1] Eric Baudin,[4] Jean Lumbroso,[4] Sophie Leboulleux,[4] and Martin Schlumberger[4]

Background: Thyroid cancer patients treated with radioiodine are potential source of radiation exposure for other individuals. Thus, we evaluated the radiation dose received by family members of thyroid cancer patients treated with ^{131}I after hospital discharge.
Materials and Methods: Seventy-six family members of 56 thyroid cancer patients were included in the study. Thyroid cancer patients were given 3.7 GBq of ^{131}I and remained in a radiation protection ward for 3 days. Radiation protection recommendations were given to patients and relatives. Life conditions were recorded and radiation doses were monitored using a personal dosimeter.
Results and Discussion: At discharge, the mean residual activity was 188 MBq. The mean radiation dose delivered to relatives during the 7 days after discharge was low (51.5 μSv) and was similar with either recombinant human thyrotropin (rhTSH) (59 μSv) or withdrawal (50 μSv) ($p = 0.37$).
Conclusion: With our current practice, radiation doses to relatives are low and well below international recommendations.

Introduction

Thyroid carcinoma is diagnosed each year in 35,000 people in the United States and in a similar number of patients in Western Europe. Many of these patients are treated postoperatively with radioiodine (^{131}I) and are potential source of radiation exposure for other individuals.

For any individual, the magnitude of exposure is related to the patient's residual activity of radioiodine, the time spent nearby the patient, and the distance during contacts. Recommendations of the National Council on Radiation Protection Measurements (NCRP) state that at the time of discharge from the hospital the dose rate at 1 m from the patient should be <70 μSv/h, corresponding to a residual activity of 1.2 GBq, and that radiation protection instructions should be given when the dose rate exceeds 20 μSv/h (1). The International Atomic Energy Agency (IAEA) and the International Commission on Radiological Protection (ICRP) state that for individuals directly responsible for care of patients, a dose constraint of 5000 μSv (5 mSv) per episode is reasonable, and that higher doses may be acceptable for parents of very sick children (2,3). All these previous data are reported in Table 1. The European Commission states that the dose constraint during each treatment with ^{131}I is 3000 μSv (3 mSv) for adult family members and 1000 μSv for children (4). Reported radiation doses to relatives varied among studies, because a wide range of ^{131}I activities was administered, patients were treated either as outpatients (5–8) or remained for a few days in the hospital (9–13), radiation protection recommendations were delivered only in some studies, and various methods were used to measure the radiation dose to relatives.

In some studies, the radiation dose to relatives was estimated by combining the patient's dose rate and a behavioral model describing contacts between the patient and relatives (5,9,10). In these studies, the highest dose received by relatives ranged from 1000 to 51,800 μSv for an administered activity of 1 to 9.3 GBq. In other studies, the radiation dose to relatives was directly measured using thermoluminescent dosimeters (6–8,11–14], and ranged from 59 to 22,200 μSv for an administered activity ranging from 0.9 to 7.4 GBq.

Reports of high radiation doses to relatives and potential exposure of the public due to ignorance or nonappliance of the rules to minimize exposure raised concern in patients and relatives, in the media, and among politicians (15).

To provide reliable information in relation with our current clinical practice, we measured with an operational dosimeter the radiation dose received by 76 relatives of 56 thyroid cancer patients who remained in the hospital for 3 days after the administration of 3700 MBq ^{131}I.

Departments of [1]Pharmacy, [2]Medical Physics, [3]Statistics, and [4]Nuclear Medicine and Endocrine Oncology, Institute of Cancerology Gustave Roussy, University of Paris-Sud, Villejuif, France.

Table 1. International Recommendations Regarding Patient Release After ^{131}I Treatment for Thyroid Cancer

	Residual activity at hospital discharge (MBq)	*Dose rate at 1 m from the patient (μSv/h)*	*Dose constraint (μSv) annual*	*Radiation safety instructions should be given when the dose rate exceeds (μSv/h)*
Recommendations of the NCRP[1]	1200 (30 mCi)	70	5,000 or more for parents of very sick children 3,000 for adult family members 1,000 for children and public	20
International Atomic Energy Agency (IAEA)[2]	800 (20 mCi)	40	5,000 or more for parents of very sick children 3,000 for adult family members 1,000 for children and public	—
European Commission[4]	800 (20 mCi)	40	15,000 for adults aged over 60 years 3,000 for adult family members aged <60 years 1,000 for children and public	—

In our study, residual activity at hospital discharge was 188 MBq, dose rate at 1 m from the patient was 5.8 μSv/h, and radiation safety instructions were given to all patients, even when the dose rate was <20 μSv/h.
NCRP, National Council on Radiation Protection Measurements.

Materials and Methods

Fifty-six consecutive thyroid cancer patients treated with ^{131}I and 76 relatives gave their written informed consent and participated in the study. This study was approved by the Institution Review Board of the Institut de Cancérologie Gustave Roussy and by the ethics committee of Bicêtre Hospital (Kremlin-Bicêtre; No. 2008-A01229-46).

Radioiodine (3.7 GBq of ^{131}I; Capsion® Cis Bio-IBA) was administered at day 0 (d0) in 36 patients after thyroid hormone withdrawal (THW) with a serum thyrotropin (TSH) level above 30 mU/L, and in 20 patients on the day after the second recombinant human TSH (rhTSH) injection (0.9 mg intramuscular, for 2 consecutive days, Thyrogen®; Genzyme) during levothyroxine treatment. Patients were hospitalized in dedicated rooms and released at day 3 (d3). Oral and written recommendations derived from the report "Radiation protection 97" (4) were delivered to each patient and relatives, to be observed during the hospital stay and after returning home (Table 2). Patients received a hyperhydration by drinking at least 1.5 L per day.

During hospitalization, whole-body retention according to time after administration was measured by external counting using an automatic, dedicated system equipped with an NaI(Tl) crystal, and the effective half-life of ^{131}I was determined (16).

Table 2. Oral and Written Radiation Safety Recommendations

Limit the duration of contact and try to maintain a distance over 1 m

Try to avoid close and long contacts (stay at >1 m and for <1 hour).
Limit any contact with pregnant women (stay at >2 m and for the shortest possible duration).
Avoid close contact with children (do not stay with children younger than 2 years during the week after discharge).
For 1 week, limit the use of public transportations, which should not exceed 2 hours. Longer trips should be undertaken only if unavoidable; in this case ask your doctor.
Avoid conception within 6 months after treatment because of the increased risk of miscarriage for women, and possible impairment of sperm for men.

Avoid contamination by saliva, sweat, and urine

Limit close contact such as hugging and sexual intercourse.
Avoid kissing, sharing dishes, towels, etc.
Stop breastfeeding completely.
Avoid splashing of urine. You must sit to urinate (male or female). Always wipe with toilet paper, and then flush. Wash your hands immediately, even if you only have urinated.

Work

Most people can work. If your job requires you to stay within a meter of the same persons for more than 2 hours a day, or if you work in close contact with young children, you should be on sick leave. Your doctor will tell you how long this restriction should apply.

Dose rates were measured at 1 and 2 m from the patient at the level of the thyroid gland and of the pelvis using 2 calibrated rate meters, an NaI(Tl)-based detector (identiFINDER, fieldSPEC-N; Target Systemelectronics GmbH) and a 500 cm^3 ionization chamber (RAMDA 2000–IC10-A probe; Rotem Industries). Values read on the rate meter were corrected from background noise. A mean value of 12 measurements and the associated standard deviation were obtained for each patient at discharge from the hospital (d3) and 7 days later (d10).

One to three persons living with the patient each received an individual operational dosimeter (DMC 2000X, MGP Instrument; range of measurement 1 μSv–10 Sv). As natural background of radioactivity combined to electronic noise of the device leads to an integrated mean value of 1 μSv per 24 hours, raw readings were corrected. At home, each relative had to wear the dosimeter at the level of the chest when the ^{131}I-treated patient was present. The dosimeter was positioned at the headboard during the night. The dose displayed by the dosimeter was recorded each day at 8:00 pm.

Information on violations of the recommendations, home description, and contacts with the patient was collected each day on a questionnaire.

At d10, the patient brought back the dosimeter and the questionnaire, and underwent another dose rate measurement, using only the sensitive NaI detector.

All relatives were recruited over early 2009 and late 2010.

Statistical analysis

Quantitative data were expressed as mean and standard deviation; qualitative data were expressed as number and frequency. All tests were two sided, and significance was assumed at $p < 0.05$. Quantitative variables were compared with Student's *t*-test or with Wilcoxon's test when the groups were too small or when data were not normally distributed. Qualitative parameters were compared with the χ^2-test for theoretical group sizes above 5, and with Fisher's test in other cases. Statistical analyses were performed with SAS software version 8.02 (SAS Institute, Inc.).

Results

Thyroid cancer patients

For the 56 patients, the mean age was 48 years (range: 18–73 years), with 19 men and 37 women. At discharge, the mean residual activity was 188 MBq (range: 36–529 MBq), which represented 5% of the administered ^{131}I activity. The residual activity was >400 MBq in 8% of patients who had functioning metastases (Fig. 1). At d3, the mean dose rate at 1 and 2 m from the thyroid gland was 5.8 and 2.1 μSv/h, respectively, and at 1 and 2 m from the pelvis was 5.3 and 1.9 μSv/h, respectively. At d10, at 1 m from the thyroid gland and from the pelvis, the mean dose rate was 0.6 and 0.5 μSv/h, respectively.

At discharge, the mean residual activity (113 MBq) in rhTSH patients was significantly lower than in THW patients (253 MBq) ($p = 0.015$), in accordance with the shorter effective half-life of ^{131}I in rhTSH patients (0.43 and 0.64 day [$p = 0.017$]) (1). The mean dose rate was significantly lower for rhTSH patients ($p \leq 0.0001$) than for THW patients, being, respectively, 3.3 μSv/h (range: 0.9–7.9 μSv/h) and 8.1 μSv/h (range: 2.5–22.3 μSv/h) at 1 m from the thyroid gland and 2.9 (range: 0.8–6.6 μSv/h) and 7.3 μSv/h (range: 2.3–20.0 μSv/h) at 1 m from the pelvis.

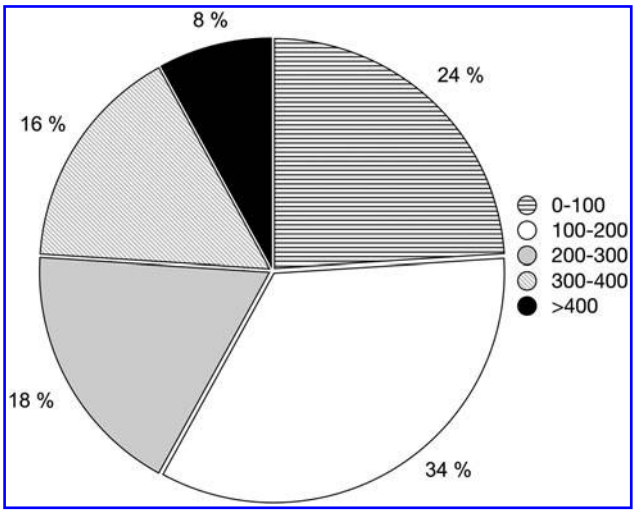

FIG. 1. Percentage of patients according to the residual activity at discharge (in MBq). The residual activity was <200 MBq in 58% of patients and >400 MBq in 8% of patients who had functioning metastases.

Relatives

For the 76 relatives (Table 3), the mean age was 40.7 years (range: 12–73 years), with 51 males and 25 females; 85% completed the questionnaire but reported that the time spent nearby the patient and behavioral changes were difficult to record precisely, but all relatives claimed that they have followed radiation safety guidelines and did not report any violation to these guidelines.

The mean time spent nearby the patient was 47 hours (range: 3–138 hours), and was shorter than 20 hours during the first 3 days in all cases.

The average housing area was 97 m^2 (range: 29–180 m^2), being similar for rhTSH patients (mean: 101 m^2; range: 43–173) and for THW patients (mean: 95 m^2; range: 29–180).

The mean cumulated radiation dose delivered to relatives during the 7 days after discharge was 51.5 μSv (range: 3–382 μSv), being <50 μSv in 77% of relatives and <25 μSv in 15% (Fig. 2). Of the total radiation dose, almost half was delivered on the day of discharge and about 15% on the second day, with 70% of the total dose being delivered during the first 3 days.

The mean cumulative radiation dose received by relatives was similar in thyroid cancer patients treated with rhTSH (59 μSv; range: 11–260 μSv) or after THW (50 μSv range: 3–382 μSv) ($p = 0.37$), and this is related to a longer time spent nearby rhTSH patients (mean: 57.2 hours; range: 9–136) than THW patients (mean: 42.6 hours; range: 3–138) ($p = 0.04$).

Discussion

In this study, the mean radiation dose to relatives over 7 days was 51.5 μSv, well below the European recommendations (3000 μSv) (3), the NCRP (5000 μSv) (1), and the annual ICRP recommendation for the public (1000 μSv) (3).

Table 3. Characteristics of the Patients, Housing Areas, and Mean Cumulative Dose to Relatives and Time Spent with the Patient During 7 Days

	All relatives		*Relatives of rhTSH patients*		*Relatives of withdrawal patients*	
Relatives	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Age (years)	40.7	19.2	41.2	20.9	40.9	18.3
Average housing area (m^2)	97	34	101	33	95	38
Cumulative radiation dose received during 7 days (μSv)	51.5	69.7	58.9	72.0	49.6	71.2
Time spent nearby the patient for 7 days (h)	47.2	34.5	57.2	32.7	42.6	35.1

rhTSH, recombinant human thyrotropin.

Interestingly, even the highest measured radiation dose (382 μSv) was lower than these recommendations.

These radiation doses are lower than those reported in previous studies that used other methods for dose measurement (5–7,9–13), but is in agreement with the average dose of 98 μSv over 7 days reported in the only study that used an operational dosimeter (8).

These low radiation doses may have been related to our routine practices. These were hyperhydration; a stay in a radiation protection ward for 3 days after the administration of 3700 MBq ^{131}I to avoid any exposure when the dose rate was high and to avoid spreading of radioactivity into the environment; and internal contamination of populations. Also, radiation safety instructions were delivered to all patients and relatives; this was not only done when the dose rate exceeded, at 1 m from the patient, 20 μSv/h (1). It was stressed that these instructions be strictly adhered to during the first days after hospital discharge.

Inevitable biases should be kept in mind: patients and relatives who accepted to enter the study may be more concerned by radiation protection, and therefore could be more careful than others, but no patient who was invited to participate to the study refused to do so. Also, because relatives were recording their habits, they may have been more cautious to minimize the time spent near the patient and to optimize the distance from the patient. Finally, the immediate readability of operational dosimeters by relatives may have led to changing their attitudes toward the patient.

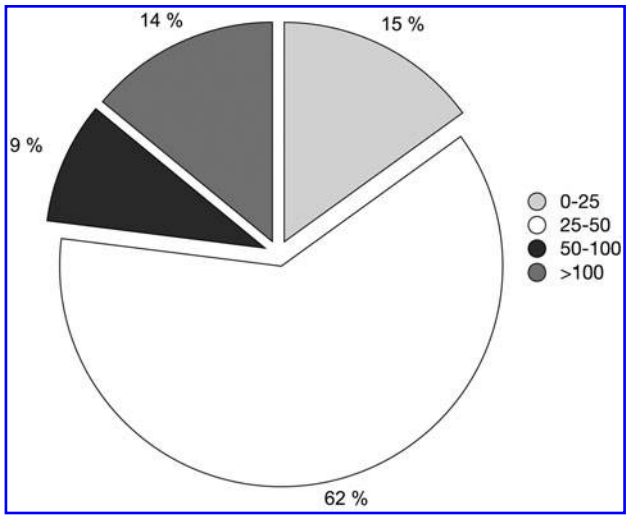

FIG. 2. Radiation dose (in μSv) to relatives during the 7 days after discharge: 77% of relatives received a total radiation dose <50 μSv, and the maximal dose was 382 μSv.

Our study is based only on the measurement of the external exposure to relatives and does not take into account the potential internal contamination. However, the ^{131}I intake by inhalation for persons in close contact to patients is very low after dismissal of a patient who remained for 3 days in a therapy ward after administration of ^{131}I, during which over 95% of the administered activity is eliminated (1,17), and recommendations were given to avoid contamination through direct contact (Table 2).

Recording the time spent in contact with the patient and behavioral changes may have been assessed differently by relatives. Indeed, a cinema session or a long travel by car or by any public transportation should be avoided. Similarly, it was recommended that contact with pregnant women and young children be avoided. However, the compliance to these recommendations may be imperfect, and this is a further reason to maintain patients in a radiation protection ward for few days after treatment.

The use of rhTSH that leads to a shorter effective half-life (16) and thus to a lower dose rate did not result in a lower radiation exposure to relatives than that delivered by THW patients. This is related to the longer time spent nearby the patient ($p = 0.04$), which is probably related to less restrictive recommendations, and this further emphasizes the relevance of these recommendations.

Conclusion

The present results are reassuring and highlight the low level of radiation received by relatives of patients treated with 3700 MBq ^{131}I for a thyroid cancer when the patient is discharged from the radiation ward 3 days after being treated and when radiation protection recommendations are clearly explained.

Disclosure Statement

The authors declare that no competing financial interests exist.

References

1. National Council on Radiation Protection Measurements (NCRP) 2004 Recent Applications of the NCRP Public Dose Limit Recommendation for Ionizing Radiation. Commentary No. 10, Bethesda, MD.

2. International Atomic Energy Agency (IAEA) 2009 Release of patients after radionuclide therapy with contributions from the ICRP (International Commission on Radiological Protection). Safety Reports Series No. 63. Vienna, Austria.
3. International Commission on Radiological Protection 1991 1990 Recommendations of the Internal Commission on Radiobiological Protection. Ann ICRP **21:**1–3.
4. European Commission and Office for Official Publications of the European Communities 1998 Radiation protection 97: radiation protection following iodine-131 therapy (exposures due to outpatients or discharged inpatients). Available at http://ec.europa.eu/energy/nuclear/radiation_protection/doc/publication/102_en.pdf (accessed 6/5/2011).
5. Barrington SF, Kettle AG, O'Doherty MJ, Wells CP, Somer EJR, Coakleyet AJ 1996 Radiation dose rates from patients receiving iodine-131 therapy for carcinoma of the thyroid. Eur J Nucl Med **23:**123–130.
6. Grigsby PW, Siegel BA, Baker S, Eichling JO 2000 Radiation exposure from outpatient radioactive iodine (^{131}I) therapy for thyroid carcinoma. JAMA **283:**2272–2274.
7. Jacobson A, Plato P, Toeroek D 1978 Contamination of the home environment by patients treated with iodine-131: initial results. Am J Public Health **68:**230–235.
8. Marriott CJ, Webber CE, Gulenchyn KY 2007 Radiation exposure for caregivers' during high-dose outpatient radioiodine therapy. Radiat Prot Dosimetry **123:**62–67.
9. Guedj E, De la Forte C, Poinsot L, Bourrely M 2003 Exposition du public et de l'entourage après traitement d'un patient par 3,7 GBq d'^{131}I pour un cancer thyroïdien différencié. Med Nucl Imag Fonctionnelle Metab **27:** 649–654.
10. Pacilio M, Bianciardi L, Panichelli V, Argirò G, Cipriani C 2005 Management of ^{131}I therapy for thyroid cancer: cumulative dose from in-patients, discharge planning and personnel requirements. Nucl Med Commun **26:**623–631.
11. Monsieurs M, Thierens H, Dierckx RA, Casier K, De Baere E, De Ridder L, De Saedeleer C, De Winter H, Lippens M, van Imschoot S, Wulfrank D, Simons M 1998 Real-life radiation burden to relatives of patients treated with iodine-131: a study in eight centres in Flanders (Belgium). Eur J Nucl Med **25:**1368–1376.
12. Mathieu I, Caussin J, Smeesters P Wambersie A, Beckers C 1997 Doses in family members after ^{131}I treatment. Lancet **350:**1074–1075.
13. Pant GS, Sharma SK, Bal CS, Kumar R, Rath GK 2006 Radiation dose to family members of hyperthyroidism and thyroid cancer patients treated with ^{131}I. Radiat Prot Dosimetry **118:**22–27.
14. Beckers C 1997 Regulations and policies on radioiodine ^{131}I therapy in Europe. Thyroid **7:**221–224.
15. NEWSLINE 2008 USA Today questions ^{131}I patient release safety. J Nucl Med 49: 20N. Available at http://jnm.snmjournals.org/content/49/1/20N.full.pdf+html
16. Rémy H, Borget I, Leboulleux S, Guilabert N, Lavielle F, Garsi J, Bournaud C, Gupta S, Schlumberger M, Ricard M 2008 Iodine 131 effective half-life and dosimetry in thyroid cancer patients. J Nucl Med **49:**1445–1450.
17. Lassmann M, Hanscheid H, Schelper LF, Korber C, Reiners C 1998 Measurement of incorporation in family members of radioiodine therapy patients after therapy of benign thyroid diseases. Nuklearmedizin **37:**120–123.

Address correspondence to:
Hervé Rémy, PharmD
Department of Pharmacy
Institut de Cancérologie Gustave Roussy
University of Paris-Sud
114 rue Edouard Vaillant
94805 Villejuif Cedex
France

E-mail: herve.remy@igr.fr

This article has been cited by:

1. 2012. *Thyroid* **22**:2, 233-233. [Citation] [Full Text HTML] [Full Text PDF] [Full Text PDF with Links]
2. 2012. Corrections. *Thyroid* **22**:2, 233-233. [Citation] [Full Text HTML] [Full Text PDF] [Full Text PDF with Links]