Effects of Early Liothyronine Consumption After Radioiodine Therapy on Accumulated Dose and Exposure Rate in Patients With Thyroid Carcinoma

Original Article

Daryoush Shahbazi-gahrouei[1]; Parvin Bonyadi[1]; Masoud Moslehi[2]; Zahra Shahi[2]

[1]Department of Medical Physics and Medical Engineering, [2]Nuclear Medicine Department, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran

(Received 16 August 2008, Revised 21 September 2008, Accepted 26 September 2008)

ABSTRACT

Introduction: Patients administered with a therapeutic dose of ^{131}I for thyroid cancer treatment are potential sources of unacceptably high radiation exposure to other individuals, particularly the patient's immediate family members. The aim of this study is to investigate effects of early liothyronine consumption after radio-iodine therapy on accumulated dose and exposure rate in patients with thyroid carcinoma. This study was also undertaken to provide specific guidelines as to when ^{131}I treated thyroid cancer patients may be safe to resume close contact with their family members.

Methods: Forty patients treated postoperatively by ^{131}I for the first time were studied. These patients were divided into two groups of twenty (group 1 with liothyronine and group 2 without liothyronine). The administered dose was 100 mCi for all patients. Thermoluminescent dosimeter chips were placed on the neck of the patients to measure thyroid dose. Liothyronine was administered 24 h after iodine therapy. Accumulated dose was measured at 12, 24, 36 and 48 h after iodine therapy. Exposure rate was also measured at 0.5, 1 and 1.5 meters from the patient's body axis with Geiger-Muller detectors at discharge time and one week later.

Results: The findings indicated that liothyronine reduces accumulated dose of thyroid and stimulates rapid washout from the body after 48 h. The patient exposure rate was significantly higher in group 2 during or one week following discharge from the hospital.

Conclusion: This study shows that liothyronine consumption decreases the exposure rate of patients at discharge time to the levels lower than that recommended by regulatory organizations.

Key words: Radio-iodine therapy, Liothyronine, Thermoluminescent dosimeter, Accumulated dose, Exposure rate.

Iran J Nucl Med 2008; 16(2): 8-15

Corresponding author: Daryoush Shahbazi-Gahrouei, Department of Medical Physics and Medical Engineering, Isfahan University of Medical Sciences, Isfahan, Iran
E-mail: shahbazi@med.mui.ac.ir

INTRODUCTION

Differentiated thyroid carcinoma occurs more frequently than any other endocrine tumor, with an annual incidence of 1.2-2.6 per 100,000 males and 2.0-3.8 per 100,000 females. Prognosis depends on age, sex, tumor stage, histological type and initial treatment (1-2). Radioiodine-131 has been used for more than 50 years to treat certain benign and malignant thyroid diseases (3). After radical surgery the activity to be administered usually varies between 1 and 3GBq, depending on the quantity and functionality of the residual thyroid tissue (4-8). Patients administered with a therapeutic dose of ^{131}I for thyroid cancer treatment are potential sources of unacceptably high radiation exposure to other individuals, particularly the patients' immediate family members (4). Generally, patients are hospitalized until such time that the retained radioactivity in the body or measured dose rate at 1 m from the patient's body surface fall within acceptable levels (4-7).

Liothyronine is the most potent form of thyroid hormone. It acts on the body to increase the basal metabolic rate, affects protein synthesis and increases the body sensitivity to catecholamine (such as adrenaline) by permissiveness (8-11). In comparison to levothyroxine (T_4), liothyronine has a faster onset of action as well as a shorter biological half-life, which may be due to less plasma protein binding to thyroxin-binding globulin and transthyretin (10-12).

Considering the risk of external radiation exposure to family members and the public, several criteria and regulations have been established to regulate hospital discharge of patients receiving radioactive treatment (4, 12). Although iodine therapy is a favor method for such kinds of thyroid diseases, there are problems of radioactive contamination. The patient can also subject family members and those who come in close contact with them (12-15).

The protocol for releasing the patient treated with ^{131}I to the general public may be different around the world. In the United states, U.S. NRC Regulatory Guide 8.39 (1) allows the release of the patient treated with more than 1.22 GBq (30 mCi) of ^{131}I provided the licensee can demonstrate that the dose to individuals exposed to the patient is less than 5 mSv (0.50 rem). However, using such a guideline in many countries may not be practical due to socio-economic differences (15, 16). Having a better understanding of the changes radiation exposure rate in the course of time following iodine administration is beneficial for radiation safety decision making.

Many studies have been performed in regard to the effects of liothyronine and levothyroxine on serum thyroid hormone concentrations and thyroid gland function, but its early effects on accumulated doses of thyroid is doubtful (10, 11). For this reason, the scope of this study is to investigate effects of early liothyronine consumption after radio-iodine therapy on accumulated dose and exposure rate in patients with thyroid cancer. This study was also undertaken to provide a more specific guideline as to when these patients may resume close contact with their family.

METHODS

Forty patients who received ^{131}I for the first time after thyroidectomy were studied. The patient population consisted of 33 females and 7 males, ranging in age from 19 to 78 years old (mean, 37 years). They were divided into two groups of twenty (group 1 with liothyronine and group 2 without liothyronine). The administered activity was the same in all patients (approximately 100 mCi of ^{131}I sodium iodide). The patient's data are shown in Table 1. In group 1, liothyronine was administered 24 h after iodine therapy.

The accumulated dose was measured with thermoluminescent dosimeter chips (TLD-100, LiF:Mg,Ti) for each patient. The TLD

dosimeters were placed on the neck and measurement was performed at 12, 24, 36 and 48 h after iodine therapy. They were dose calibrated with a ^{60}Co source located in the radiotherapy section of our center. All TLD doses were read using the Solaro 2A.
After radioiodine dose administration, the exposure rate was measured at discharge time and a week after discharge with an ionization survey instrument (Survey 200 American, Mini instrument Ltd., UK) at 0.5, 1 and 1.5 meter from the patient's upright body axis. Statistical analysis was performed by student's t-test.

RESULTS

Data for two groups of patients are shown in Table 1. Also Table 2 shows the accumulated dose measured on thyroid at 12, 24, 36 and 48 hours in two groups.

Table 1: Patients data in two studied groups.

Group 1 (with Ly)					Group 2 (without Ly)				
Patient no.	Sex	Age (y)	Thyroidectomy type	Tumor stage	Patient no.	Sex	Age (y)	Thyroidectomy type	Tumor stage
1	M	55	Hemi*	1	1	F	78	Total	2
2	F	29	Total	1	2	F	25	Hemi	1
3	M	26	Total	1	3	F	37	Hemi	1
4	F	28	Total	2	4	F	54	Total	1
5	F	19	Total	1	5	F	28	Total	1
6	F	37	Total	1	6	F	29	Total	2
7	F	40	Hemi	1	7	F	24	Hemi	1
8	F	40	Total	1	8	F	23	Total	1
9	F	30	Total	1	9	M	42	Total	2
10	F	42	Total	2	10	F	29	Total	1
11	F	36	Total	2	11	M	40	Total	2
12	F	36	Total	1	12	M	75	Total	1
13	F	40	Total	1	13	F	46	Total	1
14	F	31	Total	1	14	F	36	Total	1
15	F	43	Hemi	1	15	F	52	Total	1
16	F	42	Hemi	1	16	F	36	Hemi	1
17	F	41	Total	2	17	F	42	Total	1
18	F	39	Total	1	18	M	38	Total	1
19	F	38	Total	1	19	F	40	Total	1
20	M	40	Hemi	1	20	F	31	Total	2

*: Hemi = hemithyroidectomy and partial resection.

As Table 2 and Figure 1 show the mean accumulated dose measured by TLD found to be 8.49 cGy and 8.52 cGy at 12 h, 11.53 cGy and 11.09 cGy at 24 h after iodine therapy in group 1 and in group 2, respectively. There is no significant differences between two studied groups ($p>0.05$). Also, according to table 2 and Figure 1, the mean accumulated dose was 15.21 cGy and 12.45 cGy at 36 h, 13.23 and 11.45 at 48 h after iodine therapy in group 1 and group 2, respectively. There is significant difference between two groups ($p<0.05$).

Table 2: Accumulated dose (cGy) in two studied groups.

Group 1 (with Ly)					Group 2 (without Ly)				
Patient no	Dose 12 h	Dose 24 h	Dose 36 h	Dose 48 h	Patient no	Dose 12 h	Dose 24 h	Dose 36 h	Dose 48 h
1	8.86	12.25	17.20	13.93	1	8.43	10.37	11.74	11.34
2	7.98	10.73	15.78	14.81	2	7.97	9.62	10.67	10.64
3	6.72	7.50	10.73	8.55	3	6.41	7.57	10.58	10.19
4	8.94	12.28	16.46	15.59	4	8.08	9.51	11.90	11.02
5	9.14	12.16	13.85	11.35	5	9.82	12.20	13.85	12.25
6	7.86	9.77	13.52	11.16	6	8.78	11.63	15.70	14.33
7	7.63	11.80	14.32	12.09	7	8.41	12.45	13.04	12.10
8	8.97	12.26	14.71	12.44	8	7.06	9.81	10.45	9.12
9	7.02	8.26	13.35	11.06	9	10.12	11.19	10.57	9.04
10	7.83	9.03	13.91	10.94	10	8.91	13.74	14.18	12.79
11	8.21	11.51	15.44	13.86	11	7.89	11.12	13.10	12.41
12	9.51	16.50	18.56	16.82	12	8.41	10.57	11.02	10.21
13	8.23	11.43	14.27	12.90	13	8.99	10.86	13.96	12.13
14	10.03	12.29	17.54	16.27	14	8.46	10.71	12.82	11.51
15	8.38	12.07	15.53	12.82	15	7.99	10.41	10.92	9.21
16	8.35	11.45	15.43	13.24	16	7.98	11.24	13.26	12.21
17	9.15	13.12	17.03	15.94	17	8.56	11.75	12.32	10.44
18	8.32	11.34	14.72	12.85	18	10.14	12.87	13.58	12.41
19	8.49	12.47	15.21	12.63	19	9.78	11.85	13.02	12.45
20	10.14	12.39	16.57	15.48	20	8.12	12.45	11.97	10.18
Mean	8.49	11.53	15.21	13.23	Mean	8.52	11.09	12.45	11.29
P-value at 12 h in two groups					0.93 > 0.05				
P-value at 24 h in two groups					0.41> 0.05				
P-value at 36 h in two groups					0<0.05				
P-value at 48 h in two groups					0.02 < 0.05				

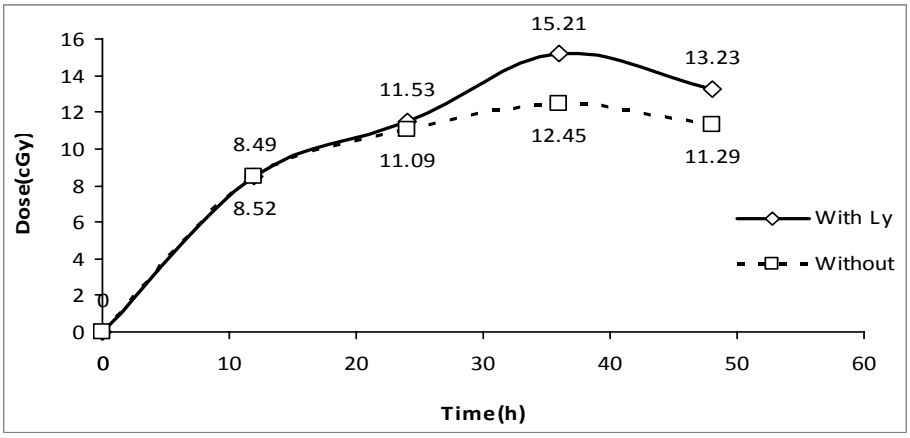

Figure 1: Comparison of accumulated dose at different times in two groups.

Table 3 shows the patient exposure rate at discharge time and a week after discharge time at 0.5, 1 and 1.5 meter from the patients in two groups. There is significant difference in all distances between two groups ($p<0.05$). Figures 2 and 3 also show the patient mean exposure rate at discharge time and a week after discharge time at 0.5, 1 and 1.5 meter from the patients in two studied groups. Measurements of mean exposure rate at discharge time and a week after discharge time was significantly different between two groups for all studied distances ($p<0.05$).

Table 3: Mean exposure rate (μSv/h) at different distances from patients at discharge time and a week after discharge time in group 1 and 2.

	Group 1		Group 2			
Distance (m)	Discharge time	A week after discharge time	Discharge time	A week after discharge time	P-value (discharge time)	P-value (a week after discharge time)
0.5	22.05 ± 0.07	1.57 ± 0.0.57	37.5 ± 1.30	2.39 ± 0.14	0 < 0.05	0 < 0.05
1	12.7 ± 0.63	0.84 ± 0.34	21.8 ± 1.01	1.35 ± 0.94	0 < 0.05	0 < 0.05
1.5	7.6 ± 0.38	0.36 ± 0.02	12.2 ± 0.06	0.61 ± 0.04	0 < 0.05	0< 0.05

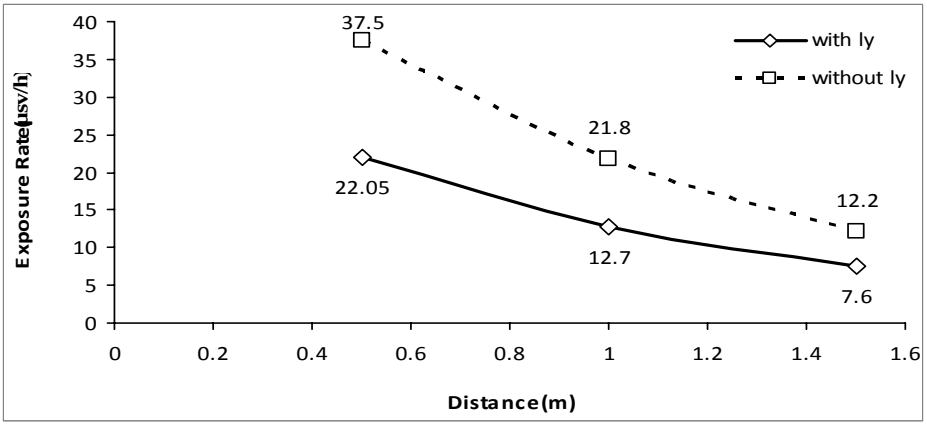

Figure 2: Comparison of mean exposure rate at discharge time in two groups.

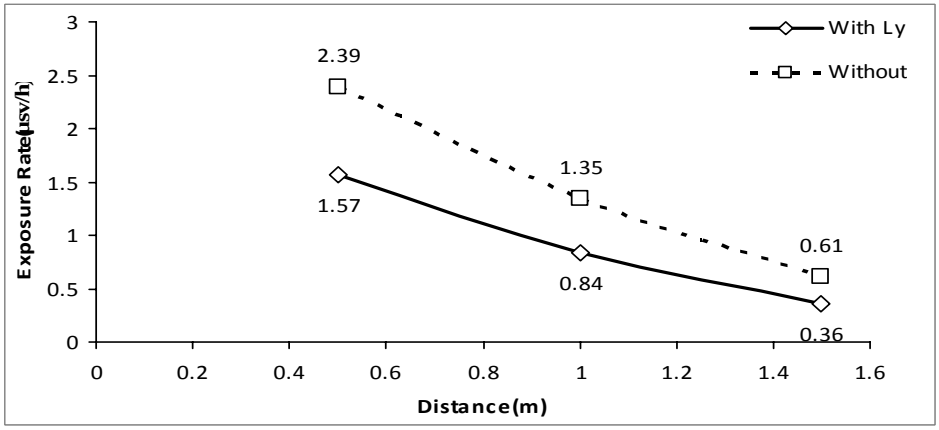

Figure 3: Comparison of mean exposure rate at a week after discharge time in two groups.

DISCUSSION

Figure 1 shows comparison of accumulated dose of thyroid at different times after iodine therapy in both groups. According to the results at 12, 24 h after iodine therapy (liothyronine was not consumed in either group), there was no significant differences ($p>0.05$). However, there was significant difference between two groups at 36, 48 h after iodine therapy ($p<0.05$) indicating that 36 h after, most of the iodine was excreted from the thyroid of the patients in group 1.

Comparison of patient exposure rate between two groups was done at the time of discharge and one week later at different distances using Geiger–Muller detector. As table 3 shows, there is significant difference between exposure rate of two studied groups ($p<0.05$). Differences between exposure rates shows good accumulated doses in thyroid and also fast excretion from the body in group 1.

The internationally recommended dose limit to the public is currently set to 1 mSv per year. However, the International

Commission on Radiological Protection (ICRP, 2004) and the International Atomic Energy Agency (IAEA, 1996) have recognized that the doses received by family members or care-givers of the patients should be viewed as medical exposure for the purpose of the limitations. Regarding this issue, the ICRP did not specify the level of dose constraint and suggested that a few mSv may seem reasonable and the IAEA explicitly recommended a dose constraint of 5 mSv during the treatment period. The dose to children and pregnant women should, however, be subject to the 1 mSv dose limit. In other words, patients can be discharged from hospital when the remaining radiopharmaceutical in their body is less than 800 MBq (15).

After the administration of a therapeutic dose, the patient can expose family members to radioactive contamination through excretion of the radioactivity in urine, saliva, bed sheet and other ways. Unfortunately, there are some cultural factors which can cause major concerns (many Iranian family, use a common room for sleeping, common vessel for eating and public transportation).

Comparison of two studied groups showed that liothyronine enhances accumulated dose in a faster rate. According to our results and statistical analysis, consumption of liothyronine causes the most iodine uptake in thyroid. This result is in good agreement with other studies (9-11).

Radiation exposure to household members from patients treated with ^{131}I for thyroid carcinoma has been measured by Grisby et al (16) but under different circumstances. This study is unique because the patients received therapeutic quantities of sodium iodide and after 24 h liothyronine was administered. One limitation of our study was that some patients underwent hemithyroidectomy and some patients underwent total thyroidectomy and the cases were not homogenous.

However, other investigators have shown that internal doses resulting from contamination and intake of ^{131}I are likely to be much smaller than external exposure to radiation from patients.

Guidelines for when patients treated with ^{131}I for thyroid cancer, may resume contact to their families at 1.5, 1 and 0.5 meters needs to restrict amount of time at discharge and no restrictions a week after discharge time (Table 3).

All of the studied cases consume liothyronine with due attention to the accumulate dose enhance in their thyroid 24 h after iodine therapy, may be safe from point of view of radiation contamination and may keep doses to other individuals “as low as reasonably achievable”. Further study includes measurement of other organ doses and also increases the number of studied patients.

CONCLUSION

Liothyronine reduces accumulated dose of thyroid and fastens excretion from the body after 48 h. Using liothyronine 24 h after iodine therapy may be a suitable method to reduce exposure rate and also to resume close contact with their family members a week after hospital discharge time.

REFERENCES

1. U.S. Nuclear Regulatory Commission. Regulatory Guide 8.39: Release of Patients Administered Radioactive Materials. Washington, DC: U.S. Nuclear Regulatory Commission; 1997.
2. Markou P, Chatzopoulous D. Isolation period prediction in patients with differentiated thyroid carcinoma treated after thyroidectomy by radioiodine–131. Hell J Nucl Med 2004; 7(3):195-198.
3. Pacilio M, Bianciardi L, Panichelli V, Argirò G, Cipriani C. Management of ^{131}I therapy for thyroid cancer: Cumulative dose from in–patients, discharge planning and personal requirements. Nucl Med Commun 2005; 26 (7): 623-631.
4. Pant GS, Sharma SK, Bal CS, Kumar R, Rath GK. Radiation dose to family members of hyperthyroidism and thyroid cancer patients treated with ^{131}I. Radiat Prot Dosimetry 2006; 118(1): 22-27.

5. Shahhosseini S, Beiki D, Dadashzadeh S, Eftekhari M, Tayebi H, Moosazadeh Rashti G. Radiation dose rate and urinary activity in patients with differentiated thyroid carcinoma treated with radioiodine-131. Hell J Nucl Med 2004; 7(3):192-194.
6. Saint-Vil D, Emran MA, Lambert R, Alos N, Turpin S, Huot C. Cumulative dose of adjunct ^{131}I treatment depend on locations of residual thyroid tissue after total thyroidectomy in differentiated thyroid cancer. J Pediatr Surg 2007; 42 (5): 853-856.
7. International Commission on Radiological Protection. Recommendations of the International Commission on Radiological Protection. USA, New York: Pergamon Press, ICRP Publication 60, 1991.
8. Appelhof BC, Fliers E, Wekking EM, Schene AH, Huyser J, Tijssen JG et al. Combined therapy with levothyroxine and liothyronine in two ratios, compared with levothyroxine monotherapy in primary hypothyroidism, J Clint Endocrinal Metab 2005; 90(5): 2666-2674.
9. Regalbuto C, Maiorana R, Alagona C, Paola RD, Cianci M, Alagona G et al. Effects of either LT4 monotherapy or LT4/LT3 combined therapy in patients totally thyroidectomized for thyroid cancer. Thyroid 2007; 17(4): 323-331.
10. Jonklaas J, Davidson B, Bhagat S, Soldin SJ. Triiodotherapy levels in athyreotic individuals during levothyroxine therapy. JAMA 2008; 229 (7):769-777.
11. Leggio GM, Incognito T, Privitera G, Marano MR, Drago F. Comparative bioavailability of different formulation of levothyroxine and liothyronine in healthy volunteers. J Endocrinol Invest 2006; 29(11): RC35-8.
12. Venencia CD, Germanier AG, Bustos SR, Giovannini AA, Wyse EP. Hospital discharge of patients with thyroid carcinoma treated with ^{131}I. J Nucl Med 2002; 43(1): 61-65.
13. Culver CM, Dworkin HJ. Radiation safety considerations for post–^{131}I thyroid cancer therapy. J Nucl Med 1992; 33 (7): 1402-1405.
14. Mohammadi H. Radiation exposure rate from ^{131}I treated hyperthyroid patients: A dynamic study with data for up to 42 days post therapy. Health Phys 2005; 88(5): 486-490.
15. Al-Haj AN, Lagarde CS, Lobriguito AM. Patient parameters and other radiation safety issues in ^{131}I therapy for thyroid cancer treatment. Health Phys 2007; 93(6): 656-666.
16. Grigsby PW, Siegel BA, Baker S, Eichling JO. Radiation exposure from outpatient radioactive Iodine therapy for thyroid carcinoma. JAMA 2000; 283(17): 2272-2274.