A study of the time of hospital discharge of differentiated thyroid cancer patients after receiving iodine-131 for thyroid remnant ablation treatment

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Abstract

The aim of this study was to measure the radiation exposure rate from differentiated thyroid carcinoma (DTC) patients who had received iodine-131 (^{131}I) treatment, and to evaluate hospital discharge planning in relation to three different sets of regulations. *We studied 100 patients,* 78 females and 22 males, aged 13 to 79 years (mean 44.40±15.83 years) with DTC, in three Groups who were treated with 3.7, 5.5 or 7.4GBq of ^{131}I, respectively. The external whole-body dose rates following oral administration of ^{131}I were measured after each one of the first three hospitalization days. A multivariant linear analysis was performed, considering exposure rates as dependent variables to the administered dose for treatment, age, gender, regional and/or distant metastases, thyroglobulin (Tg), antibodies to Tg and thyroid remnant in the three dose groups. *We found that* the exposure rates after each of the three first days of hospitalization were 30, 50 and 70μSvh^{-1} at 1m. All our DTC patients had an acceptable dose rate on days 2 and 3 that allowed their hospital discharge. After only 1 day of hospitalization, just 3/11 cases showed not permissible exposure rates above 70μSvh^{-1}. *In conclusion*, it is the opinion of the authors that after measuring the exposure rates, most treated, DTC patients could be discharged after only one day of hospitalization, even some of those treated with high doses of ^{131}I (7.4GBq). Patients, who received the higher doses of ^{131}I, should not be released before their individual exposure rate is measured.

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Introduction

Differentiated thyroid carcinomas (DTC) are the most frequent malignancies of the endocrine system, with an annual incidence in 2005 in USA, of 14.9 and 5.1 per 100,000 among women and men, respectively [1-3]. Radioactive iodine-131 (RAI) has been routinely used for the ablation of DTC remnant after total thyroidectomy, for more than 50 years [1].

Radiation hazard, a significant safety issue, consists of both external radiation hazard, through radiation emitted from the patients, and internal radiation hazard, through radioactive substances from the patients that could be ingested and contaminate others [1, 2].

Precautions and safety criteria are necessary to restrict the radiation exposure to the public, to the patients' family members and also to the staff treating these patients [3]. These safety criteria vary between countries, mainly due to various socio-economic and cultural factors. A number of guidelines and regulations, mostly based on the administered doses, have been established, in order to decide when these patients shall be discharged from the hospital [4, 5]. Usually DTC patients receiving high-dose ^{131}I treatment are hospitalized until the remaining radioactivity in their body is less than 1110MBq, or the measured exposure rate is less than 5mR/h at a distance of 1m from the patient [4]. The US Nuclear Regulatory Commission regulatory guide (No. 8.39) allows the release of DTC patients based on a measured dose rate of 7mR/h at 1m [6]. Exposure rate and discharge time, based on certain parameters and mathematical equations have been presented in a number of studies [4, 5]. Many other researchers have also proposed related guidelines [6-10] to which all do not agree.

The objective of this study was to measure the radiation exposure rate at 1m from three DTC Groups of patients who had received three different doses of ^{131}I for thyroid remnant ablation treatment, in order to decide upon the day of hos-

pital discharge [11]. Specific parameters that may alter the exposure rate have also been studied.

Material and methods

Study design

One hundred DTC patients who had been treated with ^{131}I in our Nuclear Medicine Department between 2010 and 2011 were enrolled in this study. All patients had a history of a total, or near total, thyroidectomy [11]. Thyroid remnant was poorly detected on the whole body scan (WBS).

The ^{131}I dose administered was based on several factors, including regional or distal metastases, levels of TSH and Tg.

All patients were on a low-iodine diet and had not taken any containing iodine drugs, prior to the diagnostic WBS. Diagnostic WBS was done 48h after the oral administration of 74-185MBq ^{131}I. Serum levels of thyroid stimulating hormone (TSH) (normal value, 0.3-4mIU) and anti thyroglobulin (anti-Tg) antibodies (normal value, <100ng·ml^{-1}) were measured by the immunoradiometric assay (RADIM, Italy). Thyroglobulin was measured by the radioimmunoassay method (CIS Bio International, France). All patients were duly informed about the treatment procedure and gave their written consent. The study complied with the Helsinki declaration and was approved by the Institutional Ethics Committee of Shahid Beheshti University of Medical Sciences.

We studied the following information for every patient: age, gender, tumor histology, regional or distant metastases, TSH, Tg and anti-Tg antibodies.

Patients were divided into three groups according to the administered activity: 3.7GBq, 5.55GBq and 7.4GBq. The whole body exposure rates were measured at a distance of 1m by a radiation-detector survey meter with an ionization chamber counter (Geiger-Müller GM X5C plus, Graetz, Germany) calibrated in μSv/h. For some patients for better assessment of the hospital discharge day, radiation exposure rates at a distance of 2m were also measured. The maximum dose rate from the neck area and from the upper trunk portion of every DTC patient were measured. All dose rate measurements were performed after patients had emptied their urine bladder and background was subtracted. The post-treatment dosimetry was performed on each one of the three first days following the administration of ^{131}I at a distance of 1m and for some patients at 2m on the first, second and on the third day of hospitalization (D1, 2, 3 at 1, 2m).

Our patients were 78 female and 22 male, ranging in age from 13 to 79 years (mean 44.40±15.83 years). Eighty nine patients had papillary thyroid cancer (PTC), 9 had follicular thyroid cancer (FTC) and 2 cases had Hűrtle cell carcinoma.

Thirty patients received 3.7GBq; 59 received 5.55GBq and 11 received 7.4GBq, Groups I, II and III, respectively. The exposure rates on different days are stated in Figure 1.

Statistical analysis

All data were expressed as the mean±SD, with ranges given when appropriate. Continuous variables were compared by the unpaired t test, and categorical variables were compared by x2 analysis. The relationship among clinical and laboratory factors variables with exposure rates was evaluated with multivariate linear regression model. For each model β, coefficient of each independent variables and ρ, P value were acquired. In addition, R2 value which is indicated how much of the variance in the dependent variable is explained by the model was expressed. Likewise, repeated measurements were assessed using ANOVA. A statistical P value of less than 0.05 was considered significant. Statistical package for the social sciences (SPSS) for Windows software package (Release 18, SPSS Inc., Chicago, Illinois) was used for statistical analysis.

Table 1. *Comparison age, exposure rate at 1m on days 1-3, TSH, Tg and anti-Tg antibodies, in the three groups studied*

Variable	Value (m±SD)	P value
Group I	41.5 ± 12.86	0.13
» II	44.34 ± 16.38	
» III	52.64 ± 18.58	
Total	44.40± 15.83 years	
	D1-1m	
Group I	158.00 ± 93.39	0.00
» II	162.88 ± 74.51	
» III	278.18 ± 170.10	
Total	174.10 ± 100.43 μSvh^{-1}	
	D2-1m	
Group I	33.27 ± 18.52	0.10
» II	50.64 ± 45.14	
» III	50.91 ± 22.86	
Total	45.46 ± 3.92 μSvh^{-1}	
	D3-1m	
Group I	*9(3-25)	0.10
» II	*14.50(3-75)	
» III	*18.50(7-35)	
Total	*13(8-19.50) μSvh^{-1}	
	TSH	
Group I	61.75 ± 35.36	0.22
II »	66.15 ± 42.07	
» III	44.18 ± 23.47	
Total	62.30 ±38.67 mIU·l^{-1}	
	Tg	
Group I	*1.90(2-88)	0.07
» II	*13.40(2-1900)	
» III	*270.20(1.6-1000)	
Total	*15.20(2.25-60.67)ng·mL^{-1}	
	Anti-Tg	
Group I	*68(2-915)	0.75
» II	*19(2-3000)	
» III	*19.68(5-51.7)	
Total	*25(12.42-67.50)ng·mL^{-1}	

Results

We compared age, sex, exposure rate on days 1-3, TSH, Tg and anti-Tg, in the three groups studied (Table 1). In Table 2, we describe multiple linear regression analysis for the correlation between exposure rates at 1m (as dependent variable) with age, gender, administered ^{131}I activity (as independent variables) on days 1-3 after ^{131}I administration. In Table 3, we

Table 2. *Multiple linear regression analysis of the correlation between exposure rates at 1m (as dependent variable) with age, gender and administered ^{131}I activity (as independent variables) on days 1-3 following ^{131}I administration.*

Variable		Exposure rate		
		β	ρ	R2
Day 1				0.239
	Age	0.134	0.38	
	Gender	0.47	*0.00	
	Activity adm.	0.225	0.34	
	Distant mets	0.65	*0.00	
Day 2				0.176
	Age	0.27	0.09	
	Gender	0.19	0.17	
	Activity adm.	0.52	*0.04	
	Distant mets	0.52	*0.02	
Day 3				0.166
	Age	0.30	0.06	
	Gender	0.07	0.62	
	Activity adm.	0.25	0.31	
	Distant mets	0.11	0.61	

Mets: metastases, adm: administered, β: Coefficient of each independent variables, ρ: P value, R2: This indicates how much of the variance in the dependent variable is explained by the model.

compared the number of patients having different exposure rates on days 1-3 at 1m in the three dose groups studied. The exposure rates on the first 3 days are seen in Figure 1.

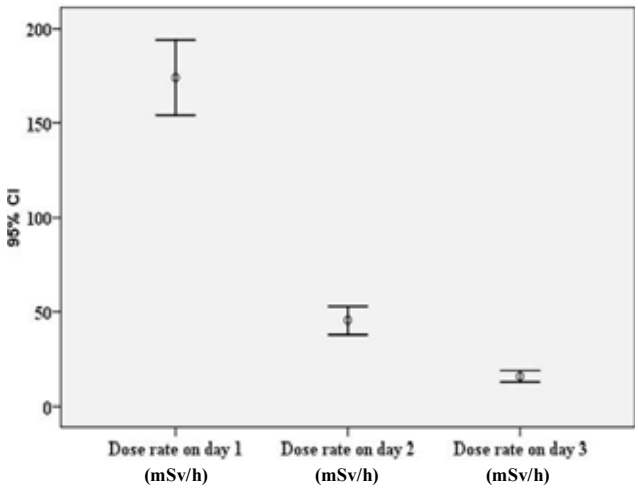

Figure 1. 95% confidence interval of the mean dose rate of the patients at 1m on each of the first three days post ^{131}I administration.

Discussion

Radiation safety hazard is the major issue following ^{131}I treatment of DTC patients and exposure rate from these patients reflects this issue [5, 12-15].

Since functional metastatic lesions cause slower RAI clearance from the body, accumulation of RAI in RAI-avid metastatic lesions increases whole-body exposure rate [1]. In our analysis, although radiation exposure was significantly correlated with distant metastases on days 1 and 2, it did not have a significant relationship on day 3. Our data demonstrated a borderline correlation between age and exposure rate, 3 days after admission. This may indicate a correlation between age and a lower clearance of RAI. However, a dosimetry survey after RAI treatment for older patients may be necessary.

Table 3. *Comparison of the number of patients having different exposure rates on days 1-3 in the three dose groups studied*

Variable	Exposure rate <30 μSvh^{-1}	Exposure rate >30 μSvh^{-1}	P value	Exposure rate <50 μSvh^{-1}	Exposure rate >50 μSvh^{-1}	P value	Exposure rate <70 μSvh^{-1}	Exposure rate >70 μSvh^{-1}	P value
D1-1m									
Group I	0	30		2	28		5	25	
» II	0	59	-	0	59	0.09	2	57	0.04
» III	0	11		0	11		0	11	
Total	0	100		2	98		7	93	
D2-1m									
Group I	20	10		25	5		28	2	
» II	13	46	0.00	47	12	0.75	52	7	0.54
» III	3	8		8	3		9	2	
Total	36	64		80	20		89	11	
D3-1m									
Group I	29	1		30	0		30	0	
» II	54	5	0.29	57	2	0.49	57	2	0.49
» III	9	2		11	0		11	0	
Total	92	8		98	2		98	2	

In addition, the multivariate linear analyses for the parameters in different days showed a significant relation between exposure rate and administered activity on day 2. This relation in the other two days was also positive but when adjusted for the other clinical and laboratory parameters failed. The average exposure rate may be altered due to patients' prescribed activities, age groups, gender, weight, the volume of functioning thyroid, the volume of metastatic tissue, and the rate of renal and bowel excretion [1].

Discharging most of the patients after 1 day of hospitalization with instructions about how to keep the dose emitted to other persons "as low as reasonably possible" has many advantages, besides fewer hospital stays, that is to: reduce the radiation exposure of hospital personnel, lower health care charges, provide psychological advantages for patients and families, and improve the quality of life of patients. Studies of family members of DTC patients undergoing outpatient ^{131}I treatment for DTC have mentioned that provided the appropriate instructions decreases radiation exposure of primary caregivers to <5mSv [12-15].

In 1997 the Nuclear Regulatory Commission (NRC) revised the regulations regarding hospital discharge of DTC patients following treatment with ^{131}I [16]. The previous patient- release criteria was the retained activity (<1,110MBq) or an exposure dose rate at 1m <5mrem/h. The new patient-release criteria limits the total effective dose equivalent (TEDE) to <500mrem for the most exposed individual. The regulations of NRC expressed in a revision of Title 10, Part 35.75 [16] and in the Regulatory Guide 8.39 [16], state that RAI can be used with a TEDE limit of 5mSv as a default value for ^{131}I activity, 1,221MBq, or with exposure rate at 1m of 7mrem/h, or by estimating the patient-specific dose.

We released our patients if the dose rate fell below 10μSv/h (1.0mR/h) at a distance of 1m, and most of our cases met this release-criterion value after 3 days. Earlier discharge is most welcome.

The limitations of this study are: a) the relatively small number of cases and b) the absence of behavioral factors like the number of baths the patient is taking, that may have an impact on the obtained parameters.

In conclusion, it is the opinion of the authors that after measuring the exposure rates most treated, DTC patients could be discharged after only one day of hospitalization, even patients that had received high doses of ^{131}I (7.4GBq). It also demonstrates that patients who received high doses of ^{131}I, could be released based on the individual patient exposure rate measurement.

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The authors declare that they have no conflicts of interest.

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