The impact of body mass index on the external dose rate from patients treated with radioiodine-131: A preliminary study

Original Article

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ABSTRACT

Introduction: The relation between patient Body Mass Index (BMI) and the external dose rate of thyroid cancer patients treated with ^{131}I has been investigated.

Methods: A total of 183 patients treated with ^{131}I were selected randomly and divided according to their administrated activity into three groups: 3.7GBq, 5.5GBq and 7.4GBq. They were also stratified into three groups according to their BMI values namely normal, overweight and obesity. A telescopic radiation survey meter was used to measure the dose rate at 1 meter from patient neck level. The measurement was effectuated after 1, 24 and 48 hours post dose administration.

Results: Our findings showed that regardless the patient sex, age, and administrated dose, the external dose rate values in normal BMI range patient group were higher by 11% (as an average) as compared to overweight and obesity groups when the dose administrated was 150 and 200 mCi while it was higher by 49% for patient received 100 mCi.

Conclusion: The BMI patient value may be taken into account in the radiation protection optimization process by the physicist during isolation period and general public after patient discharge.

Key words: Radiation protection; Body mass index (BMI); I-131; Therapy

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INTRODUCTION

Most patients with thyroid cancer are treated with radioiodine-131 as targeted therapy. When considering radiation safety precautions for attending personnel, members of the general public, and patients in adjacent rooms, it is important to remember that ^{131}I emits both negative β particles (maximum energy approximately 807 keV) and a prominent gamma ray (364 keV). It delivers the major portion of the radiation dose to the remnant thyroid tissue, and it is the penetrating gamma that poses a potential radiation hazard to others outside the patient's room. Once the patient is dosed, regulations may require a short period of isolation in the medical facility, typically 2 to 3 days, until radiation exposure rates drop to acceptable levels [1-3]. It is during this time that the greatest potential exists for contamination and radiation exposure problems [4-6]. The topic of releasing patients treated with radioiodine has been discussed in many research papers [7-10]. The releasing criteria are only based on either the administrated activity or the external dose rate measured at 1 m from patient. The Body Mass Index (BMI) is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults as defined by World Health Organization. BMI values are age-independent and the same for both sexes. However, BMI may not correspond to the same degree of fatness in different populations due, in part, to different body proportions. Four main international classifications of adults according to BMI values were adopted: underweight for BMI < 18.5, normal range between 18.5 and 24.9, overweight from 25 up to 29.9, and obese for BMI ≥30 [11]. The correlation between BMI and patient radiation dose was discussed in several papers, as in diagnostic radiography in mammography [12], Computed tomography [13] and Coronary Angiography [14], also, in radiotherapy [15]. However, the patients treated with radioiodine may have different anthropometric measures. The association of various body size parameters with the external dose rate due to an administrated dose of radioiodine has not been previously addressed. The purpose of this study was to analyze measurements of the external dose rate of a randomized sample of thyroid cancer patients treated with ^{131}I as function of different BMI group classification to explore any eventual relation.

METHODS

In this study, a total of 183 patients treated for thyroid cancer with ^{131}I in AL-Bayrouni hospital (near Damascus) were monitored during the period from February to August 2011. The patients were selected randomly with an inclusion criteria consisting of a negative human chorionic gonadotrophin measurement in women. Patient's anthropometric measures (weight, height, age) were recorded. Patients were stratified according to the administrated activity into three groups: 3.7 GBq (58.5%), 5.5 GBq (32.2%) and 7.4 GBq (9.3%) as shown in Table 1. In the group A the patient age range was from 20 to 79 years, in the group B, it was from 21 to 76 years while in the group C, it was from 27 to 69 years. For each group, patients were also assigned to the one of three subgroups based on their body mass index (BMI): normal weight (BMI 18.5-24.9 kg/m2); overweight (BMI 25-29.9) and obese (BMI ≥30). Table 2 shows the mean values of anthropometric measures of the patients.

In order to measure the external dose rate of patients, the GRAETZ Telescope Probe DE with Dose Rate Measuring System GRAETZ X 5 C plus, calibrated in the Secondary Standard Dosimetry Laboratory of Syria, was used. This survey meter detects and measures beta and gamma rays dose in microsieverts with associated uncertainty better than 10% for a confidence level of 95% as provided by the calibration procedure in the measurements range of 1.0 $\mu Sv.h^{-1}$-20 $mSv.h^{-1}$ as it is approved by PTB (Physikalisch-Technische Bundesanstalt, Germany).

The external dose rate was measured by a physicist at the thyroid level of the patient and at a distance of 1 m from the effective point of measurement of the survey from the standing patient. In addition, a movable shielding barrier was used to minimize the physicist occupational radiation dose. So the telescope Probe DE was used for measuring high dose rates from a safe distance (at 4 meters from patient).

Table 1. The Patient groups.

Patients group	Administrated dose of ^{131}I (The activity)	No. of patients		
		Male	Female	Total
Group A	3.700 GBq (100 mCi)	15	92	107
Group B	5.550 GBq (150 mCi)	19	40	59
Group C	7.700 GBq (200 mCi)	5	12	17
Total of Patients		39	144	183

Table 2. Anthropometric measurements of patients in the groups (A, B and C).

	Normal weight		Overweight		Obese	
	Mean	±SD	Mean	±SD	Mean	±SD
Group A						
Age (Year)	38.41	17.81	40.64	12.88	45.58	11.01
Weight (kg)	58.97	6.58	71.04	6.57	89.49	12.49
Height (cm)	161.35	4.68	160.86	6.65	159.45	6.89
BMI (kg/m2)	22.62	1.96	27.42	1.44	35.26	5.08
Group B						
Age (Year)	37.50	11.38	36.80	10.76	46.96	13.42
Weight (kg)	56.71	4.98	75.40	10.69	90.37	13.31
Height (cm)	158.08	6.64	165.00	7.58	158.70	5.70
BMI (kg/m2)	22.68	1.20	27.56	1.65	35.96	5.59
Group C						
Age (Year)	30.25	3.95	48.33	10.93	43.29	8.01
Weight (kg)	62.50	5.26	73.83	11.48	91.94	13.87
Height (cm)	163.50	8.70	163.17	11.96	163.43	10.60
BMI (kg/m2)	23.41	1.71	27.62	1.61	34.35	3.06

RESULTS

The measurements of external dose rate of 183 patients were performed at 1, 24 and 48 hours post dose administrated at 1 m from standing patient at the thyroid level. The mean±SD dose rates at 1 m for the three administrated groups A, B and C are summarized in the Table 3 for normal, overweight and obese body mass index (BMI) subgroups. All patients were restricted to radiation isolation into the hospital for 3 days, as the external dose rate criterion for releasing patient described by Syrian authority at 1 m from the patient must be less than 30 $\mu Sv.hr^{-1}$ [16].

DISCUSSION

Regardless the patient sex, the administrated dose, and the level of acquired measurement; the average dose rate at 1 meter was in the range of 18.89 to 310.38 $\mu Sv.hr^{-1}$ after 1 hour of dose administration, while the average dose rate at 1 meter was in the range of 31.57 to 77.50 $\mu Sv.hr^{-1}$ after 24 hour of administration, and the average dose rate at 1 meter was in the range 11.06 to 29.67 $\mu Sv.hr^{-1}$ after 48 hour of administration. It is clear that the isolation period of 3 days was justified as the patient discharge external dose rate is limited to 30$\mu Sv.hr^{-1}$.

The external dose rates measured form the patients in the same administrated patient group were slightly different from one BMI group to another. Figures 1, 2 and 3 show the variation of the average dose rate values in the different patients body mass index groups after 1, 24 and 48 hours, respectively.

After one hour of dose administration, the average external dose rates from patients in the overweight and obese BMI groups (in all A, B, and C groups) were lower from that from normal range BMI group. The average differences in overweight and obese BMI groups regarding to normal BMI group were -9.31% and -18.32%, respectively. However, after 24 hours from dose administration, the average external dose rates of overweight BMI group trend to be lower than the dose rates for patients from normal BMI group. The maximum difference was -28.57% for patients in group B while the average of differences was -13.22%. In the obesity BMI group, the average external dose rates were only lower for patient group B and C by -11.29% and -28.57%, respectively but it was higher for patients in group A by 19.02% as compared to the normal BMI group.

Table 3. Measured dose rate at 1 m from patients of groups A, B and C (μSv.hr^{-1}).

Patient group	Time after dose administration (h)	Normal weight		Overweight		Obesity	
		Mean	±SD	Mean	±SD	Mean	±SD
Group A	1	143.06	28.30	125.65	18.89	122.50	23.76
	24	32.74	10.42	31.57	10.61	38.96	16.56
	48	11.06	5.98	11.32	5.55	16.14	11.11
Group B	1	210.63	39.87	182.60	47.80	173.89	27.30
	24	59.50	28.13	42.50	19.84	52.78	22.05
	48	25.17	21.92	13.30	6.92	21.85	15.34
Group C	1	306.88	32.93	299.33	82.05	235.86	24.06
	24	77.50	9.00	71.67	21.28	55.36	26.16
	48	26.50	4.04	29.67	12.27	17.50	11.18

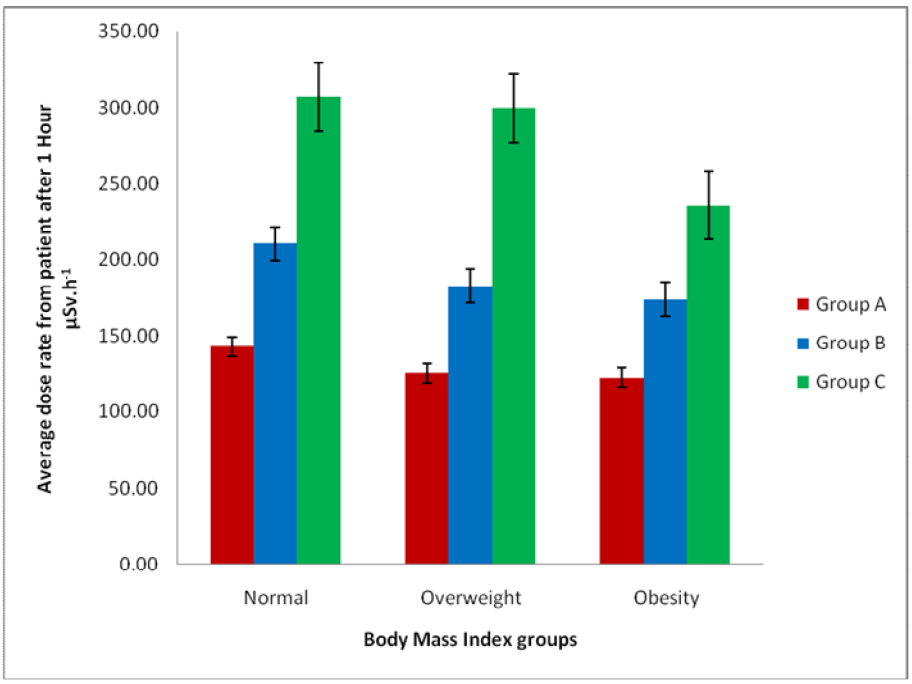

Fig 1. The variation of dose rate values after one hour from patients groups regarding to the body mass index groups.

The average dose rates after 48 hours from dose administration in overweight BMI group as compared to normal BMI group were higher for patient group A and C and lower for patient group B. while the average patient group A dose rate was higher in the obesity BMI group as compared to normal BMI group. Table 4 shows the relative change of dose rate values in overweight and obese groups respectively in comparison to the patient normal BMI group. The maximum difference between overweight and normal BMI group was in the range from -9.31% to -13.22% for all patient administrated groups (A, B and C) while the average BMI change value was 20%.

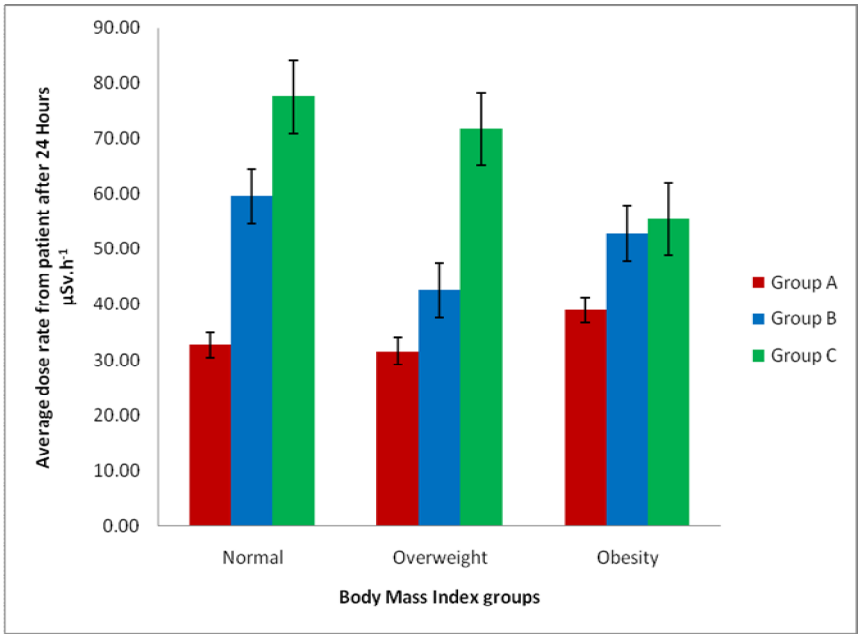

Fig 2. The variation of dose rate values after 24 hours from patients groups regarding to the body mass index groups.

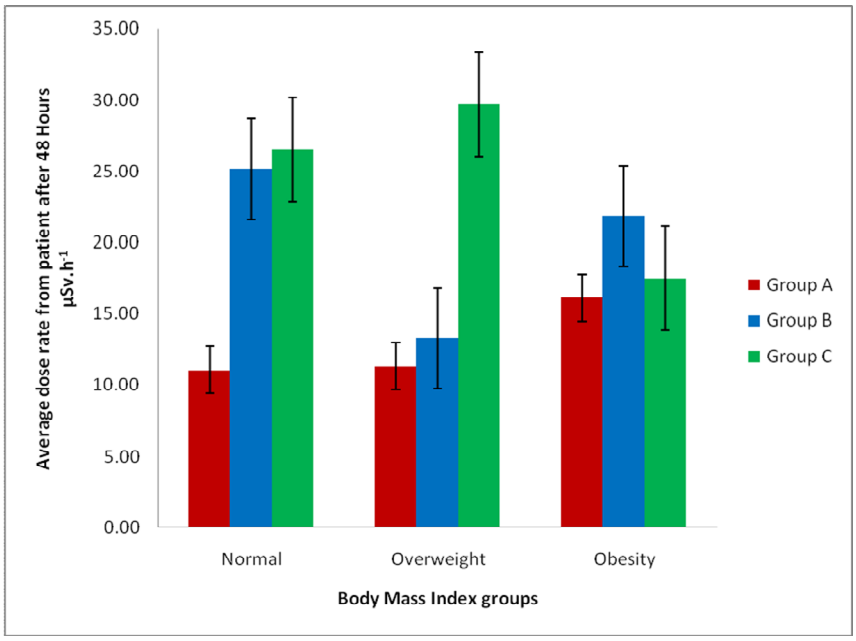

Fig 3. The variation of dose rate values after 48 hours from patients groups regarding to the body mass index groups.

The difference dose rates between obese and normal BMI groups were in range from -0.40% to -18.32% for all patient administrated groups (A, B and C) while the average BMI change value was 53.73%. The results show that the radiation emitted from normal BMI patient group trend in general to be higher in about 11% than that emitted from overweight or obese patient for high dose administration (Groups B and C), which can be explained by the increase of the attenuation of gamma rays in overweight and obese BMI patient groups. Also, it can be taking into consideration for radiation protection of public or physicists during patient isolation period in the hospital.

Table 4. Relative change of external dose rate of overweight BMI and obesity patient groups regarding to BMI normal group.

		Group A	Group B	Group C	Average
Overweight BMI patient group to BMI normal group					
Mean relative BMI factor change		21.00%	22.00%	18.00%	20.00%
Relative external dose rate after	1 hour	-12.17%	-13.31%	-2.46%	-9.31%
	24 hours	-3.56%	-28.57%	-7.53%	-13.22%
	48 hours	2.36%	-47.15%	11.95%	-10.95%
Obesity BMI patient group to BMI normal group					
Mean relative BMI factor change		56.00%	59.00%	47.00%	53.73%
Relative external dose rate after	1 hour	-14.37%	-17.44%	-23.14%	-18.32%
	24 hours	19.02%	-11.29%	-28.57%	-6.95%
	48 hours	45.96%	-13.19%	-33.96%	-0.40%

On the other hand, the radiation dose emitted from obesity BMI patient group treated by 100 mCi (Group A) was higher by 45% as compared to the normal BMI patient group. In fact, the patient sample was selected randomly, and the number of patients in each group was not equal, which may influence the results obtained statistically.

CONCLUSION

Regardless the patient sex, age, and administrated dose, the external dose rate values in normal BMI range patient group were higher in average of 11% as compared to overweight and obese groups for 150 and 200 mCi doses administrated while it was higher by 49% for patient administrated by 100 mCi. The BMI patient value may be taking into account in the radiation protection optimization process of the physicist during patient isolation period and for general public after patient discharge.

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