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Estimation of radiation dose of emergency exposure during the hospitalized ^{131}I therapy patient

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► ***Short report***

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ABSTRACT

Background: The aim of the study was to estimate the radiation dose during emergency exposure to patients treated with iodine-131 during the isolation period. ***Materials and Methods***: The dose rate from a sample of 192 patients administrated by three different radioactivity of ^{131}I (3.7, 5.55 and 7.4 GBq) was measured, at 1 meter after 1, 24 and 48 hours post dose administration, at three different levels from the patient body (thyroid glands, abdomen and knee). The average of decay curve of the measured radiation dose rate was plotted and their values were fitted. The medical emergency exposure was estimated in the form of an equation to take into account the duration and the position of the intervention. ***Results:*** The estimated radiation doses received during 10 minutes of intervention emergency at a distance of 20, 40 and 60 cm from patient after different times post dose administration were in the range of 72.2 to 1207.5, 18.1 to 301.9 and 8.0 to 134.2 µSv, respectively. ***Conclusion:*** During the first ten hours following patient dose administration, the estimated emergency dose could be considered as high occupational dose value compared to the dose limit recommended by ICRP.

Keywords: *Radiation protection, emergency exposure, ^{131}I radiotherapy, radiation safety precautions.*

INTRODUCTION

Many types of cancer and some other non-malignant diseases can be treated with radiations emitted by radionuclides. Most patients with thyroid cancer are treated with radioiodine-131 for targeted therapy [1]. Oral administration of ^{131}I has been a widely accepted procedure for treatment of benign and malignant conditions of the thyroid since the 1940s [2, 3].

Generally speaking, direct external radiation from patient and inhalation of ^{131}I are possible sources of significant dose to other persons. Exposure to these sources should be prevented or reduced as far as is reasonably possible. In addition to personnel irradiation, external and internal contaminations are potential hazards to personnel entering the patient's room after administration dose [4]. 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. During this time, the greatest potential exists for contamination and radiation exposure problems. The releasing criteria is based on either the administrated activity or the external dose rate measured at 1 m from patient. The regulatory authority in Syria has a specific regulation for patient release from the hospital adopted from the BSS-115 and states that the patient may be released from the licensee's control either when activity levels within the patient drop below 1.11 GBq (30 mCi), or dose rates at 1 meter from the patient drop below 30 µSv/h [5, 6].

During the isolation period, safety precautions control the ordinary relation between patients and medical staff in order to provide the necessary protection from the radiation emitted from patient [7]. However, in case of patient illness or accident requiring

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attendance by a doctor for medical emergencies, such as cardiac or respiratory arrest, seizures or trauma, the primary goal is set to provide the appropriate emergency medical and nursing attention to the patient, while at the same time controlling radiation exposure to medical staff must be guaranteed. If the time allows, prior to entering the room, disposable glove, shoe covers and gowns should be worn [8]. Also, it is important to estimate the radiation dose of the involved medical staff occurred from this emergency exposure.

The purpose of this study was to analyze the measurements of dose rate as a function of time and distance to quantify the radiation dose arising from the thyroid cancer patients treated with ^{131}I in order to estimate the radiation dose to persons subject to any emergency or accidently exposure resulted during the isolation period of patient in the case of emergencies.

MATERIALS AND METHODS

The GRAETZ telescope probe DE with dose rate measuring system GRAETZ X 5 C plus were used to measure the radiation dose rate from patient administrated with ^{131}I. This survey meter is annually calibrated at the National Radiation Metrology Laboratory (NRML) in Syria. The uncertainty associated with survey measurements was provided by the calibration procedure and was better than 10% for a confidence level of 95%. The measurements range of this system is 1.0 μSv/h – 20 mSv/h, as it was approved by PTB-Germany, which is suitable to measure the dose rate from patient. The telescope probe DE was used for measuring high dose rates from a safe distance at 3 meters from patient, also, a movable shielding barrier was used to minimize the occupational radiation dose.

A total of one hundred ninety two randomly selected patients received ^{131}I therapy for thyroid cancer in AL-BAYROUNI University Hospital (Damascus) were surveyed during the period from February to August 2011. The administered activities ranged from 1.11 to 7.7 GBq (30 to 200 mCi). The patients were classified into three groups according to their administered doses as shown in table 1.

The dose rate, in μSv/h, for each patient was measured at 1, 24 and 48 hours post dose administration at a distance of one meter from the surface of patient at three different levels of the body: thyroid, bladder and knee level.

In order to calculate the radiation dose resultant from any potential interventional emergency procedures to a patient treated by iodine-131 at 1 meter, the decay of dose rate (μSv/h) at one meter from the patient was plotted and their values fitting was calculated. Figure 1 shows the decay of average dose rate (μSv/h) at 1 m from the patient with their quadratic fitting.

The radiation dose of the emergency procedures to a patient treated by iodine-131 during the isolation period can be calculated using this formula:

$$D = \frac{\dot{D} \times t}{d^2} \qquad (1)$$

Where:

D: Dose received during emergency procedure in μSv.

$\dot{D}$: The dose rate (μSv/h at 1 meter), which can be obtained from the respected curve of the administrated activity in figure 1 or from its fitting equation.

d: Approximate distance (m) between the exposed person and the patient during the emergency intervention.

t: The duration of emergency procedure (in hours).

Table 1. Patient groups according to administrated activity of ^{131}I.

Patient group	No. of patients			
	Male	Female	Total	% of Total
Group A (3.7 GBq)	16	93	109	**56.77 %**
Group B (5.55GBq)	23	41	64	**33.33 %**
Group C (7.4 GBq)	6	13	19	**9.90 %**
Total of Patients	45 (23.44%)	147 (76.56%)	192	

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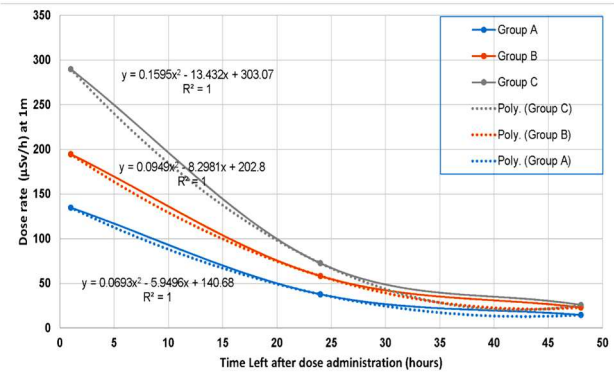

Figure 1. The average radiation dose from patients treated by iodine-131 at 1 m.

RESULTS AND DISCUSSION

The dose rate from each patient was calculated as the average of the measured dose rates at the different three levels. Table 2 shows the minimum, maximum and average dose rate at 1 meter for each patient groups according to administrated activity of ^{131}I.

The average dose rate at 1 meter for all groups (A, B and C) were ranging from 134.8±27.7 to 289.8±58.0, 37.8±14.4 to 72.6±23.9 and 14.74±9.9 to 25.9±11.6 µSv/h for 1, 24 and 48 hours post dose administration respectively. Obviously, the average dose rates is related to the post administration time, and it increased significantly as the administrated doses of ^{131}I increased.

For a hypothetical emergency case which happened after 15 hours of patient administrated by 5.55 GBq of ^{131}I and demonstrated by a patient fall down in unconscious state into his isolation room. The emergency procedure required attendance by a doctor for a medical assistance for 20 minutes while the approximate distance between patient and the doctor was about 40 cm. The received radiation dose by doctor can be calculated from the equation (1) as the dose rate value after 15 hours could be estimated from the curve of the average radiation dose of patient in group B, so the doctors could receive a dose of 216.56 µSv.

Table 3 shows the estimated emergency dose received during 10 minutes of emergency procedures after different time from administration dose at 20, 40 and 60 cm from the patient. The estimated value in the presented example and some value in table 3 could be considered as high occupational dose value compared with the dose limit recommended by ICRP 103 [9] especially if these cases repeated frequently. As an example, for a 5-minute of emergency intervention, the received dose is considered as high dose during the first ten hours following the patient dose administration for all groups. However, the estimated emergency dose values are still below the emergency worker dose mentioned in the international basic safety standard for the purposes of saving life or preventing serious injury [10].

It's important that the emergency medical staff have the necessary level of radiation protection knowledge to maintain their occupational dose as low as possible. It should be required before entering the patient isolation ward to wear the disposable glove, shoe covers and gowns. In addition, a personal radiation dosimeter is essential to carry for emergency medical staff and keep distance to the patient skin and visit duration to minimum when possible.

Table 2. Average dose rate at 1 meter from patient groups for different times.

Time of measurements	Patient Group	Dose rate (µSv/h) at 1 m		
		Minimum	Maximum	Average
1 hour	A	81.0	223.3	134.8 ± 27.7
	B	114.0	273.7	194.6 ± 32.8
	C	212.0	316.7	289.8 ± 58.0
24 hours	A	16.0	84.7	37.8 ± 14.4
	B	20.3	101.3	58.3 ± 19.0
	C	30.0	117.3	72.6 ± 23.9
48 hours	A	2.7	51.3	14.74 ± 9.9
	B	5.0	57.0	23.1 ± 13.1
	C	5.7	49.3	25.9 ± 11.6

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Table 3. Estimated emergency received dose in μSv* during 10 minutes for different distances.

Time after dose administration (Hours)	Distance (cm)								
	Group A			Group B			Group C		
	20	40	60	20	40	60	20	40	60
1	**561.7**	140.4	62.4	**810.8**	**202.7**	90.1	**1207.5**	**301.9**	134.2
5	**469.4**	117.4	52.2	**682.0**	**170.5**	75.8	**999.6**	**249.9**	111.1
10	**367.1**	91.8	40.8	**538.8**	134.7	59.9	**769.6**	**192.4**	85.5
15	**279.3**	69.8	31.0	**415.3**	103.8	46.1	**572.8**	143.2	63.6
20	**205.9**	51.5	22.9	**311.7**	77.9	34.6	**409.3**	102.3	45.5
25	146.9	36.7	16.3	**227.8**	56.9	25.3	**279.0**	69.7	31.0
30	102.3	25.6	11.4	163.6	40.9	18.2	**181.9**	45.5	20.2
35	72.2	18.1	8.0	119.2	29.8	13.2	118.1	29.5	13.1

*The numbers in bold are considered as high occupational dose value comparing with the dose limit recommended by ICRP 103.

CONCLUSION

Radiation doses of medical emergency exposure during isolation period of patients treated by ^{131}I were theoretically calculated and a mathematical equation was established for estimation of doses taking into account the duration and the position of the intervention. The estimation was based on the average of the decay curve of radiation dose measured at 1 m from a sample of 192 patients administrated with three different radioactivity. In some cases, the estimated emergency dose from patient is found to be a high occupational dose especially during the first ten hours post dose administration so the radiation safety recommendations must be respected.

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Conflict of interest: *Declared none.*

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