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RADIOACTIVE DISCHARGE FROM PATIENTS WITH THYROID CANCER UNDER ^{131}I TREATMENT AND ITS SAFE DISPOSAL TO PUBLIC DRAINAGE

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ABSTRACT

The treatment of thyroid cancer using an unsealed source of radioactive materials is usually associated with a large amount of ^{131}I. A major problem for hospital admission of these patients is the waste disposal which requires protection of the public.

152 patients with thyroid cancer admitted to the nuclear medicine department of Said Al–Shohada Hospital for ^{131}I treatment were studied. ^{131}I excreted from these patients during isolation was calculated. Exposure from patients were measured using a Victorian 190F survey dosimeter.

More than 70 percent of the administered ^{131}I was excreted after 24 hours, 90 percent after 48 hours and 96 percent after 72 hours of isolation. The mean biological half life of ^{131}I in patients with thyroid cancer was found to be 13.9±1.9 hours. There was no significant difference between the mean effective half life in the patients related for the first time and second time at 95 percent significance level.

The results of this study showed that the difference in the discharge rate of ^{131}I from patients with thyroid cancer receiving first and second treatment was not significant. The mean discharge rate after the first 24 hours was more than 70%, and it was more than 96% after the third 24 hours of drug administration. The results can be used to design safe collecting and discharge methods of the wastes.

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Keywords: Thyroid cancer, Radioactive waste discharge, Biological half-life, Radiation dose.

INTRODUCTION

Treatment of thyroid cancer using unsealed sources of radioactive materials is usually associated with a large amount of ^{131}I. To protect the public, it is required to isolate the patients until the retained radioactive drug in the patient's body is reduced to an acceptable level.[1] The reduction of the radiodrug from the patient's body is governed by two factors of physical and biological half-life of the administered material.[2] Since the physical half-life of ^{131}I is much longer than its biological half-life in cancerous thyroid tissue, its excretion is mostly governed by its biological activity.[3] A major problem in hospital administration of these patients is the waste disposal. Disposal of the excretion in such patients is governed by the Radioactive Substances Act 1993. In this document the maximum activity that can be disposed during a certain period of time is specified. There are various recommended methods for disposal of the wastes. The most convenient method is to dispose the patient's urine directly into the public drainage. To reduce the dose disposed to the public to an acceptable level as suggested by the International Commission on Radiological Protection (ICRP)(1990), it is necessary to reduce the disposed radioactive concentration at the time of discharge to about 370Bq/Lit. The most common practice is to store these wastes for a suitable length of time

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for physical decay, then after appropriate decay time and dilution, discharge them in public sewage. Accurate measurement of the excreted activity from these patients for suitable planning and patient administration is necessary.

In some previous studies a guideline for 30% and 50% excretion of the administered activity is provided.[4]

Laranson et al[5] measured ^{131}I released from hospital excretion of the patients treated with thyroid cancer. The presented results were of limited value as the number of the patients was limited.

In this study the activity discharged from 152 patients with thyroid cancer treated with ^{131}I to the sewage as aqueous waste during the hospitalization period was measured.

MATERIAL AND METHODS

^{131}I reduction from a patient's body depends on the physical (T_{phy}) and biological (T_{bio}) half lives of ^{131}I. Measuring exposure (A) from the patient at any time (t) and comparing with the exposure at the time when the drug is administered to the patient (A_0) and using the equation $A=A_0e^{t/Teff}$, the effective half life (Teff) can be calculated. Using the equation $T_{eff} = (T_{phy} . T_{bio})/(T_{phy} + T_{bio})$, T_{bio} can also be calculated. With the above data the amounts of ^{131}I discharged from the patient at any time can be calculated. The remaining ^{131}I in the collecting tank (the tank used to collect the discharge from patients) can be calculated at any time (details are explained in the discussion part).

152 patients referring to the nuclear medicine department of Said Al-Shohada Hospital from the beginning of this study were selected. The hospital has two separate isolation rooms for radioactive iodine therapy. The study period was from 21 September 2001 till of November 20, 2002. The ^{131}I was administered to the patients in the form of NaI with different amounts.

Dose measurement was performed using a Victorian 190F dosimeter fixed on the doors of the isolation rooms. To reduce random fluctuation and errors, the cumulative dose for each patient at each time was measured for one minute. The measurements were repeated every 24 hours. The first measurements for each patient were performed immediately after ^{131}I administration. All the measurements were done with the same geometrical set up. The distance between dosimeter and patient was 1 meter in all cases. The dosimeter was fixed on the door at the belt level of the patients. Usually each patient was retained in the hospital isolation room for three days. But in some cases with lower activity administration and high activity discharge rate the retention time lasted for 2 days.

Table I. Distribution of the patients in terms of the administered ^{131}I (in GBq). Groups I and II are the groups of patients treated for the first and second time respectively.

Administered drug	3.7	4.625	5.55
Number of patients in group I	60	28	19
Number of patients in group II	28	5	12

RESULTS

Distribution of the administered activity is shown in Table I. In this table, group I are those patients being treated with ^{131}I for the first time while group II are those being treated for the second time.

The mean and SD of the measured dose rate per mCi of administered activity at 1 meter for different groups of the patients and at different times are shown in Table II. Table III shows the retention percentage of the activity in the patients' bodies at 24, 48 and 72 hours after administration of ^{131}I, respectively. The percentage was obtained by dividing the results of each measurement for a patient by the first measurement in the same patient. The percentage distribution of the discharged activity during first, second and third 24 hours from the administration time are shown in Figure 1. These percentages were calculated by reducing the retention percentage from 100.

DISCUSSION

In a nuclear medicine department large amounts of

Table II. Distribution of the mean and SD of the measured dose rate at belt level per mCi administered ^{131}I at 1 meter from different groups of patients at 0, 24, 48, and 72 hours after administration (μGy/h/mCi).

Time	t= 0h	t= 24h	t= 48h	t= 72h
Measured dose in group I	2.2±0.51	0.55±0.28	0.14±0.08	0.04±0.03
Measured dose in group II	1.93±0.45	0.48±0.13	0.14±0.09	0.05±0.03

Table III. The remaining percentage of the radio-drug in the body after 24, 48 and 72 hours.

Remaining percentage of radiopharmaceutical in patients	0-10	10-20	20-30	30-40	40-50	50-60
Percentage of the patients after 24 hours	4	28	34	18	13	4
Percentage of the patients after 48 hours	52	25.7	15.1	7.2	0	0
Percentage of the patients after 72 hours	85.5	10.5	4	0	0	0

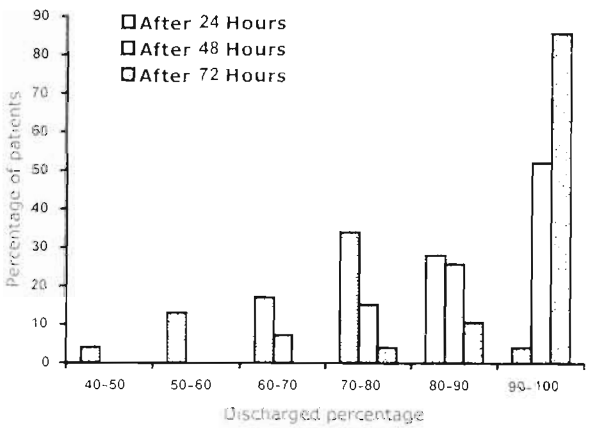

Fig. 1. The percentage distribution of radio-drug discharged from the patients after first, second and third 24 hours of drug administration.

radioactive materials are used daily. Especially in those departments having ^{131}I therapy units, a large portion of the administered drug is excreted in the drainage system. The environmental impact requires evaluation of the concentration of radioactive materials in the sewages. It is also important to provide appropriate installation to retain the excreted drug for an appropriate interval and then discharge it in the public drainage.

The Environmental Agency is currently reviewing the practice of disposing liquid radioactive waste to the public drainage systems.[5,6] An important consideration is the restriction of public and the sewage workers from the discharge waste which should be below the dose limits.

The results of this study showed that the rate of activity dischrged by the patients receiving different amounts of radiopharmaceutical ^{131}I for the treatment of thyroid cancer was not significantly different. Table II shows that more than 70% of the administered drug was discharged during the first and more than 90% after the second 24 hours of hospitalization in both groups. This finding is not in agreement with the results of Driver and Packer which is about 85% after 3 days of isolation.[11] The mean effective half lives for ^{131}I obtained from the results of this investigation are 14.5±2 and 13.3±1.8 for both groups of patients. The differences between the two mean effective half lives were compared using t-test. The difference was not significant at 95% significance level ($p<0.05$).

The mean effective half-life obtained from this research was 13.9±1.9. Comparing it with the physical half life of ^{123}I which is 8 days, shows that $T_{eff} \sim 0.9 T_{bio}$.

Assuming that the excretion of the administered activity from the patient is only through urine, and the urine is collected in a reservoir tank for extra decay and after an appropriate time is discharged to the public sewage, the total activity (At) excreted from n patients with isolation period of Δt for each patient and collected in the tank can be approximated as follows:

$$A_t = A_{10}(1-e^{-\gamma_b \Delta t})\, e^{-\gamma_p t}\, Z^n_t\, e^{t\gamma_p \Delta t}$$

A_{10} is the activity excreted from each patient (assuming this is the same for all patients), and γ_b and γ_p are the biological and physical decay constants for iodine in patients with thyroid cancer.

If the volume of the collecting tank is assumed to be V then the concentration of the activity in the tank (C) when it is full is:

$$C = A_{t\cdot V} = A_t/mxn$$

m is the amount of urine in liters, discharged from each patient during isolation period and n is the number of the patients until the tank is full. Assuming that the concentration limit of the radioactive waste to the public sewage is C_0 (B_q/lit) then the duration t (after the tank is filled) necessary to reach this level can be obtained from the following equation:

$$Cp = Ce^{-\gamma pt} = (A_t/mxn)e^{-\gamma pt} < C_0 \text{ (Bq/lit)}$$

If a hospital has q therapy rooms then the activity to the tank will be qxA (q can be assumed to be the number of therapy rooms or it can be assumed as an occupational factor which is the number of therapy rooms and the occupation factor).

CONCLUSION

According to this study the mean biological half-life of ^{131}I for patients with thyroid cancer is 13.9±1.9 hours. It is also found that excretion rate is not significantly different comparing patients treated for the first and second time. The excretion rate after the first 24 hours is more than 70% and more than 95% after 72 hours of drug administration. Based on the above results, a mathematical model for collected activity excreted from n patients treated with ^{131}I and safe discharge is suggested.

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