Journal of the Nigerian Association of Mathematical Physics
Volume 31, **(July, *2015*), pp 325 – 330**

Radiation Effective Doses To Caregivers Of Patients On ^{131}I (Radioiodine) Therapy Forcancer of The Thyroid at University College Hospital (UCH), Ibadan, Nigeria.

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Abstract

The Effective doses (ED) received by caregivers of patients on ^{131}I (iodine-131) treatment for cancers of the thyroid have been measured. The measurements were carried at the Nuclear Medicine Department of University College Hospital (UCH), Ibadan. High sensitivity tissue equivalent thermo luminescent dosimeters (TLDs) were used for measuring the doses received by 25 caregivers who assisted 7 patients treated with various doses of ^{131}I (Iodine-131). The number of caregivers who supported the treated patients was between 2 and 5 caregivers per patient. The mean doses received by the caregivers ranged from 0.11 to 0.92 mSv per patient. Additionally, the mean doses received by teenagers, young adults and adults were 0.31, 0.34 and 0.24 mSv respectively. The mean dose received by the caregivers is below the limit of 5.0 mSv recommended by the US Nuclear Regulatory Commission indicating that the caregivers considered in this study are at lower radiological health risk. The trend in this study shows that low doses could be achieved with adequate restriction and compliance with the safety instruction in developing countries.

Keywords: Caregiver of patients; Effective dose; Iodine-131; Teaching Hospital, Thyroid cancer

1.0 Introduction

It is a common practice to use ^{131}I for the treatment of benign and malignant thyroid disease. Iodine-131 has been used for over 50 years to treat hyperthyroidism and thyroid cancer. Radioiodine produced in a nuclear reactor as a product of fissioning of uranium 235 (^{235}U). The nuclear reaction leading to the production of radioiodine is shown in equation (1).

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{236}_{92}U \rightarrow ^{131}_{53}I + ^{102}_{39}Y + 3^{1}_{0}n \quad (1)$$

For chemical separation of ^{131}I from the irradiated ^{235}U target, the latter is dissolved in 18% NaOH by heating and hydroxides of many metals ions are precipitated by cooling. The supernatant containing sodium iodide is acidified with sulphuric acid in a closed distillation system. Iodide is oxidized to iodine by the acid, and iodine is collected in NaOH solution by distillation [1]

The treatment with^{131}I used to: kill any cancer cells that may have been left behind after thyroid removal, treat thyroid cancer that has spread (metastases), and the treatment of recurring cancer [2]. It is expected that benefit accrued to patients treated with radioiodine must be balanced against radiation exposure to caregivers, the family members and other public members [3]. This is in line with the Nuclear Regulatory Commission (NRC) regulations and, in addition, ensures that the radiation dose to other individuals is as low as reasonably achievable (ALARA) as maximizing the benefits of the treatment.

The nature of treatment, living condition of patients and the dose received by the patients are the determining factors whether a patient remains as an in-patient or an out-patient after the administration of iodine-131.There is no consensus as to how treatment should be performed.

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However, four general approaches have been used. The first is the use of a standard activity of 185 MBq with treatment repeated if necessary to achieve desired outcome [4]. In this approach, neither the weight/volume of the patient thyroid nor the iodine turnover rate (uptake and excretion) is taken into account. The second approach is to use the standard activity per unit mass of the thyroid gland usually 1.85 – 7.4 MBq/g. In the third approach, each patient is administered with individual patient-specific calculated activity taking into account the 24 hour uptake of iodine in the gland. The fourth approach is used most commonly in the UK, where different standard activities at different hospitals in the range 185-800 MBq are delivered [5]. In this method, higher activities are used to avoid repeated treatment. The fourth method is adopted at our institution, University College Hospital, Ibadan.

The treatment outcome is of course of utmost importance when deciding which treatment plan to adopt. Some centres aim at reaching euthyroid state while others are satisfied with the patient to no longer be hyperthyroid. At our institution the desired outcome is generally for the patient to become euthyroid. That is to have a normally functioning thyroid gland. If the principle of ALARA is to be followed, then an optimized treatment protocol is vital. Studies have shown that there are cases where patients have been treated with 2.5 to 8 times the required activity [4], therefore exposures to both patients and relatives have been excessive.

Previous standard guidelines state that patient receiving less than 1100 MBq and with a dose rate less than 16 μSvh^{-1} at a distance of 2m [6,7] . Radioiodine treatment of in-patient using high dose may pose risk to both the personnel (staff) and the public (including family members) during support or comfort of the patient [8]. Earlier guidance on dose limit requires that the dose limit to the caregivers must never exceed the general dose constraint of 5 mSv, taking into account distance, shielding and time. The recommendation of the International Commission on Radiological Protection report 105 stipulates that a dose constraint of 5 mSv per episode for the caregivers. The young children, infants and visitors are treated as members of the public; therefore their doses are required to be kept within 1 mSv per year [9]. This work is an effort at assessing the optimization of radiation protection, safety and compliance to standard procedures in our treatment of cancer of thyroid patients and exposure scenario to the public. It is essentially important to measure the effective doses received by caregivers of patients treated with ^{131}I during their hospitalization at the Department of Nuclear Medicine of University College Hospital (UCH), Ibadan.

2.0 Materials and Methods

Seven patients consisting of two males and five females whose average age are 37 years admitted to the Nuclear Medicine Department and treated with various doses of ^{131}I were considered in this study. The sample size issmall because of the few number of patients treated at the hospital; however, the sample size was considered sufficient for the purpose of this study. The weight and the age of the patient were recorded before administering the radioiodine therapy. Twenty five caregivers, basically relations of the patient were included in the study. The age of the caregivers ranged between 14 and 75 years. A radio- pharmacist measured the required activity (dose) of the radioiodine for each patient before it was administered. The measurement was carried out in the hot laboratory using dose calibrator. The activity (dose) was checked by a Medical Physicist who also administered it to the patient. After the administration of the radioiodine, each patient was requested to rest for about 30 minutes to ensure that no side effects occurred.

Immediately after the administration of ^{131}I to each patient, the Caregivers were issued calibrated and pre-annealed TLD badges after necessary discussion on the rules and regulations bothering on safety and interaction with the patient. Risks associated with caregiving were discussed with the volunteers. The badges were to be worn by Caregivers at whole body level for a period of 14 days corresponding to about two times the effective half-life of ^{131}I. Each patient was duly informed about the study and given consent form to fill and sign. External dose rate at various distances were measured using dose rate meter.

3.0 Results

Table 1 shows patient data, activity administered during the treatment of each patient, number of Caregivers who attended to each patient and the average dose received by Caregivers from each patient during the period of two weeks of supporting the treated patients. The table also indicates the diagnosed condition of each patient as at the time of treatment. The mean doses received by all Caregivers per patient range from 0.13mSv to 0.67 mSv. Result of mean dose received by the 25 Caregivers was less than a dose limit of 1 mSv for general members of the public.

Result in Table 2 shows data obtained from the caregivers during a period of 14 days of caregiving and support of the hospitalized patients. Column 2 of Table 2 indicates that teenagers (14, 15, and 16 y) and young adults (18, 20, 22 and 24 y) were included among the Caregivers. The doses received by each Caregiver during the period of investigation range between 0.11 and 0.92 mSv. The upper limit is close to the required dose limit of 1 mSv to the general public.

Table 1: Patient data, activity of ^{131}I administered to the patient and average dose received per Care giver

Patient	Sex	Age (y)	Weight (kg)	Numberof Care givers (n)	Condition of patient	Administered Activity (mCi)	Mean dose received by Care givers (mSv) per patient
P1	M	14	53.5	5	PTC	53.2	0.22
P2	F	25	60.0	3	HP	11.5	0.13
P3	F	75	89.5	4	HP	50.0	0.25
P4	M	29	48.8	5	PTC	200.0	0.67
P5	F	44	92.8	2	FC	80.0	0.17
P6	F	28	53.8	3	PTC	330.0	0.15
P7	F	45	78.0	3	HP	61.0	0.15

PTC=Papillary thyroid cancer, HP=Hyperthyroidism, FC= follicular Carcinoma

The result in Table 2 shows that a teenager (≤17 y)and a young adult (≥18 y) received doses of 0.76 mSv and 0.67 mSv respectively. A careful observation of Table 3 indicates that the mean effective dose received by the teenagers (Caregiver) included in the investigation was 0.31 mSv while the young adult (18-24 y) received an effective dose of 0.34mSv. It is also evident that the mean dose for both teenagers and young adult was 0.33 mSv. The mean values of doses for teenagers and young adults obtained in this study are less than the required dose limit. Moreover, the mean dose received by the adult patient was 0.24 mSv. This dose is lower than the mean doses received by both teenagers and young adult Caregivers.

Table 2: Caregiver data and dose received during support

Care giver	Age (y)	Weight (kg)	Average dose received by each Caregiver (mSv)
G1	26	72.0	0.15
G2	18	53.0	0.53
G3	75	116.0	0.17
G4	20	61.5	0.11
G5	55	89.0	0.14
G6	20	62.5	0.11
G7	65	90.0	0.13
G8	25	75.0	0.16
G9	52	72.0	0.20
G10	22	67.0	0.28
G11	56	90.0	0.33
G12	24	70.0	0.19
G13	20	56.0	0.56
G14	30	80.0	0.92
G15	20	66.8	0.52
G16	18	60.0	0.67
G17	16	55.0	0.76
G18	14	54.0	0.17
G19	55	90.0	0.17
G20	50	75.0	0.15
G21	16	60.0	0.15
G22	32	70.0	0.16
G23	50	90.0	0.15
G24	15	62.0	0.16
G25	18	60.0	0.13
	Mean Dose		0.29
	SEM		0.046
	range		0.11-0.92

Figure 1 shows the external dose rate measured at various distances from the treated patients (gastrointestinal tract level, 1m and 2m). The dose rate measured at gastrointestinal tract (GIT) level is higher in all the patients than the dose rate measured at distances of 1 m and 2 m respectively. The dose rates were measured immediately after ingestion of ^{131}I capsule. The high dose rate at GIT level is expected since ^{131}I capsule "sit" in the stomach before absorption into the thyroid. This dose rate is capable of giving high dose rate equivalent to the Caregivers. Therefore, the Caregivers are required to keep at a distance of at least 1 m from the patient while attending to the patient for the period of 24 hours after the radioiodine therapy.

Table 3: Age group of Caregivers and mean effective dose

Age group of Caregivers	n	Age range (y)	Effective dose (range) mSv	Meaneffective dose (mSv)
Teenagers	4	13-17	0.15-0.76	0.31
Young adult	9	18-24	0.11- 0.67	0.34
Adult	12	≥ 25	0.13-0.92	0.24
Both teenagers and young adult	13	13- 24	0.11-76	0.33

Moreover, it is expected that the dose rate measured at a given distance be higher if higher activity was administered. However, it is evident from Figure 1that the dose rate at GIT level from a patients who received about 53.2mCi (8940 μSv/h) and 80 mCi (3980 μSv/h) compared to 2450 μSv/h from a patient who received about 200 mCi. The dose rate trend found in this study is multifactorial [rate of absorption (uptake), metabolic rate and age of patient]. The low dose rate experienced at a distance of 1 m and 2m respectively, is an indication that the dose received by Caregivers depends on the distance between caregiver and the patient.

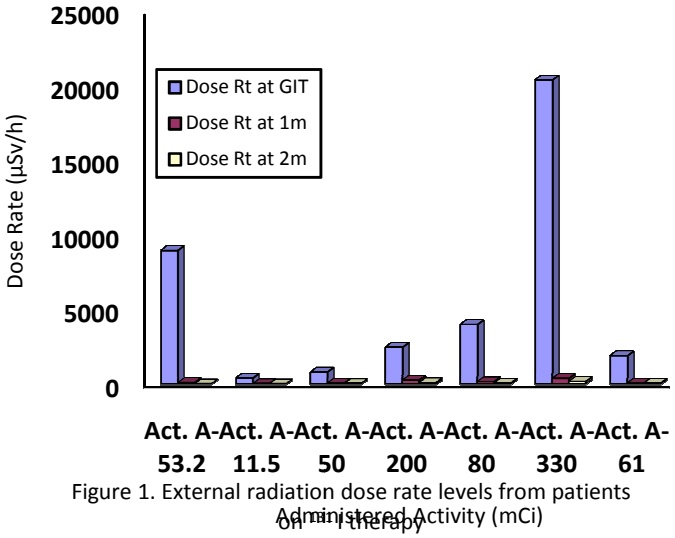

Figure 1. External radiation dose rate levels from patients on ^{131}I therapy

4.0 Discussion

All the seven patients considered in this study were hospitalized for at least 14 days. The practice of keeping patient as an inpatient bothers on; the health condition of the patient, the living condition of the patient, dose administered and the availability of Caregivers. There are some advantages of keeping patient treated with radioiodine for thyroid carcinoma as an outpatient are; reduced of expenses of treatment and less psychological strain on patient [10]. However, the cultural practice of many household members keeping at the bedside (as the case of multiple Caregivers in this study) of the outpatient treated without complying with the safety regulations and without restriction could lead to large dose being delivered to the Caregivers.

The result in Table 1 (column 8 row 4) and Table 2 (G13 – G17) indicate a relatively high mean dose for P4.The Patient, P4 was treated for papillary thyroid cancer and administered 200 mCi. All the Caregivers (perhaps his siblings) were female with age range between 16 and 30 years. The patient was a weak patient and almost incapacitated and required close monitoring and care than all other patients. This condition probably explains the reason for higher mean effective dose received by his Caregivers (0.67 mSv). However, such relatively high dose could be attributed to non-compliance with instruction on caregiving and perhaps emotional attachment of the caregiver to the weak patient (rather than considering the reason given in the safety instruction). It is evident from Tables 2 and 3 that the doses received by the Caregivers are lower in all cases than the required dose limit for the public. This shows that the doses that the Caregivers in this study received fall below the acceptable dose limit, therefore they are at lower health risk.

Some of activities involved in caregiving when a patient is weak or incapacitated include: change of diapers, assisting patient with bathing, emptying of urinary bags and containers, and changing of beddings. The major sources of radiation dose to the Caregivers include; external exposure and contamination.

However, contamination from the patient treated with radioiodine does not dependent on amount of radioactive ^{131}I; it is strongly dependent on the patient compliance with safety instruction, patient behavior, nature of the treated part and the rate of uptake. As a result of the large amount of activity excreted by the patient during hospitalization, contamination hazard may arise from ^{131}I via urine, saliva and perspiration and potential vomitus [11]. Radioiodine is secreted in body fluid such as sweat and saliva and excreted into urine and faeces [12]. The secretion and excretion of radioiodine could result in the contamination of the patient and of inadvertent ingestion by other person [13]. This contamination poses risk to the relation of patient and community members through external rays and body fluid of the treated patients. In order to limit the dose received by the Caregiver, it is required that each member of the public keeps away from the treated patient especially immediately after the administration of radioiodine.

Additionally, special lead apron or garment could be assigned to the Caregivers when patients are hospitalized. The lead apron is indeed essential for female, teenagers (because of the expected longer life span and their being more radiosensitive than adult) and young adult Caregivers. The doses received by most of the subjects considered in the study are well below the reference dose limit, however, one of the limitations of the study was that the investigator did not take into consideration the pregnancy status of the female subjects within the age of conception prior to being allowed to support the treated patient. It is a necessity and a requirement that pregnant women should be strictly restricted from the treated patient or at least be kept at a distance from him. About 40% of the caregivers were within the conception age, however, the pregnancy statuses of the caregivers were not known before they were permitted to take part in the care giving activities. The pregnancy status is an important factor for the consideration of a female volunteer as caregiver of patient treated with radioiodine.

In this study the effective dose received by all patients is far below the dose limit (5mSv) of IAEA and EC guidance level for family and close friend per treatment with ^{131}I to adult up to 60 years [8, 13], therefore, they are at lower health risk

5.0 Conclusion

The effective doses received by Caregivers of patients treated with radioiodine were measured. The practice of several caregivers attending to a patient hospitalized is found to be effective in reducing the dose received by Caregivers if adequate restriction could be adopted, such that each of the multiple caregivers is allowed a short period with the patient; and thereby reducing the occupancy period. On the other hand, the cultural practice of multiple-caregiving with no restriction could lead to extremely high effective dose to the Caregivers. Results of the study show that using the cultural practice of multiple-caregiving, the dose measured are generally lower than the required dose limit (indicating that each caregiver has a short contact time with the patient, thus receives low doses and are at lower health risk). Nevertheless, it is also essential to consider the pregnancy status of the female supporters before being enlisted as a caregiver.

6.0 Acknowledgements

The authors would like to thank the Staff of Nuclear Medicine, University College Hospital (UCH), Ibadan
for their assistance during the investigation. The authors also express their gratitude to the staff of National Institute of Radiation Protection and Research (NIRPR) for allowing the use of their TLD cards and Reader.

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