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Effective doses to family members of patients treated with radioiodine-131

M Zdraveska Kocovska¹, O Vaskova¹, V Majstorov¹, S Kuzmanovska¹, D Pop Gjorceva¹ and V Spasic Jokic²

¹ Institute of Pathophysiology and Nuclear Medicine, Medical Faculty, University of “Sts Cyril and Methodius”, Skopje, Former Yugoslav Republic of Macedonia

² Technical Faculties, University of Novi Sad, Serbia

E-mail: mzk2003@hotmail.com

Abstract. The purpose of this study was to evaluate the effective dose to family members of thyroid cancer and hyperthyroid patients treated with radioiodine-131, and also to compare the results with dose constraints proposed by the International Commission of Radiological Protection (ICRP) and the Basic Safety Standards (BSS) of the International Atomic Energy Agency (IAEA). For the estimation of the effective doses, sixty family members of sixty patients, treated with radioiodine-131, and thermoluminescent dosimeters (Model TLD 100) were used. Thyroid cancer patients were hospitalized for three days, while hyperthyroid patients were treated on out-patient basis. The family members wore TLD in front of the torso for seven days. The radiation doses to family members of thyroid cancer patients were well below the recommended dose constraint of 1 mSv. The mean value of effective dose was 0.21 mSv (min 0.02 - max 0.51 mSv). Effective doses, higher than 1 mSv, were detected for 11 family members of hyperthyroid patients. The mean value of effective dose of family members of hyperthyroid patients was 0.87 mSv (min 0.12 - max 6.79). The estimated effective doses to family members of hyperthyroid patients were higher than the effective doses to family members of thyroid carcinoma patients. These findings may be considered when establishing new national guidelines concerning radiation protection and release of patients after a treatment with radioiodine therapy.

1. Introduction

Many types of cancer and some other non-malignant diseases can be treated with radiations emitted by radionuclides. The unsealed radionuclides, that are injected, ingested, or inhaled, and which move through the body, are referring to as radiopharmaceuticals. These can localize in body tissues until they decay or they can be eliminated through various pathways, such as sweat and saliva and excreted into urine and feces. The radionuclides used for radiopharmaceutical therapy are usually relatively short-lived beta emitters. Most of these radionuclides also emit photons, which usually contribute minimally to the treatment dose, but produce an undesirable radiation field emanating from the patient.

The most frequently used radiopharmaceutical for the treatment of thyroid diseases, such as Thyroid Cancer and Hyperthyroidism, is radioactive iodine-131. It has very high success rate in the treatment of patients with thyroid diseases and it has also proven to be safe and a relatively inexpensive treatment. The treatment renders the patient radioactive. The patients, treated with radioactive iodine-131, present a radiation hazard to other individuals such as hospital staff, the

patient's family and members of the public with whom a treated patient may come in close contact. This situation can be overcome by imposing restriction on the behavior of the patient, to minimize the dose to close relatives and other individuals. In 1991, the International Commission of Radiological Protection (ICRP) [1] has recommended a radiation constraint of 1 mSv/y to the general population. According to the Basic Safety Standards Directive (BSS) [2], the dose limits to the general public are not valid for "exposure of individuals, who are knowingly and willingly helping, other than as part of their occupation, in the support and comfort of in-patient and out-patients undergoing medical diagnosis or treatment". Proposed dose constraint from the BSS is: 0.3 mSv per episode for public, 1 mSv for children, 3 mSv for adults up to sixty years of age, and 15 mSv for adults more than 60 years old.

The implementation of this guideline differs between countries. In the Institute of Pathophysiology and Nuclear Medicine, Skopje, about 50 thyroid cancer patients are treated on in-patient basis and, approximately, the same number of hyperthyroid patients are treated, ambulatory, on out-patient basis.

According to the local hospital rule and the old guidelines, the maximum given activity to hyperthyroid patients, treated on out-patients basis, is 1110 MBq. The new, not yet established guidelines, proposed to reduce the maximum given activity to hyperthyroid patients, treated on out-patient basis, to 555 MBq. This group of patients presents great radiation hazard to their family members. Upon discharge from hospital, the patients as well as their family members are given brief radiation safety instructions.

The aim is to minimize the transfer of radioactive material to persons coming in close contact with the patient. There are several papers in the literature concerning the subject of doses received by family members of thyroid cancer and hyperthyroid patients [3-8]. Most of the published studies agree that doses to the family members are below the proposed dose constraint of 1 mSv. But there are also several papers [5, 9] that present cases where children or other persons have received higher radiation doses than the proposed dose limit and, usually, this is the case with hyperthyroid patients and their relatives.

2. Purpose

The main purpose of this study was to estimate the radiation exposure to family members of patients treated with radioiodine-131 either for thyroid carcinoma or hyperthyroidism at our nuclear medicine centre. The other purpose was to use the results to identify necessary restrictions to ensure that the recommended dose constraint proposed by ICRP and the BSS of IAEA are met.

3. Materials and methods

The study population comprised thirty family members of the same number of thyroid cancer patients and thirty family members of thirty hyperthyroid patients. The administered dose for the treatment of thyroid cancer patients ranged from 3700 MBq to 5550 MBq of radioiodine-131. Mean administered dose was 3539 MBq. Twenty six patients received 3700 MBq, two patients received 4440 MBq and two patients received 5550 MBq.

They were hospitalized for three days after administration and their dose rate was measured every day at a distance of 0.25 m, 0.5 m, 1.0 m and 2.0 m by a medical physicist. The dose rate measurements were performed with a calibrated survey meter "mini-rad" series 1000, Morgan. When the level of 8 μ Sv/h at 2 m was reached, the patients were released from hospital. Upon discharge, the patients were given radiation safety instructions for their further behavior, in order to minimize the transfer of radiation to persons coming in close contact with them, especially children and pregnant women. Their relatives wore the TLD for one week and they were informed not to stay very close to the patient; and if so, to reduce the time of staying. It was suggested to maintain the distance between them and patient more than 2 m and to reduce time of staying to less than 10 minutes up to one hour.

Hyperthyroid patients were treated with 185 MBq to 1295 MBq of radioiodine-131. Mean administered dose activity was 683 MBq. External dose rate measurements were performed at the

same distance as thyroid cancer patients, fifteen minute after administration of therapy. Afterwards, they were released from hospital.

All the patients were interviewed and were informed about the research aims by a medical physicist and a physician. They signed an agreement for participating in the study. Family members groups consisted of 12 females and 18 males in the hyperthyroid group and 24 males and 6 females in the thyroid cancer group. Their age varied from 15 up to 80 years. The effective dose measurements were carried out with thermoluminescent dosimeters, model TLD 100, which contain 3 mm² hot pressed chips of lithium fluoride (LiF:Mg,Ti), encapsulated between two sheets of Teflon 10 mg/cm² thick and mounted on an aluminium substrate with-bar code and within shielded filter holders (type 8814 Harshaw). The detection threshold of the dosimetry system is 0.0054 mSv. TLD's were most appropriate to estimate radiation because the amount of ionizing radiation is directly proportional to the effective dose [10]. Actually, the depth dose Hp (10) was estimated. These types of dosimeters have photon energy response for gamma rays that ranges from 15 keV - 3 MeV (IEC 1066). The TLD Reader and Cards are calibrating on a regular basis. The combined standard uncertainty of a dosimetry system is less than 15%. Control TLDs were kept separately to measure the background. The background readings were subtracted from the dose readings of the relatives.

4. Results and discussion

4.1 Thyroid cancer patients

Table 1 presents the effective dose to relatives of the thyroid cancer patients treated with radioiodine-131 and measured with TLD dosimeters. The TLDs were worn by the relatives for one week. The range of the effective dose varied from 0.02 mSv to 0.51 mSv. For three family members, the TLD showed a value of 0 mSv and the explanation was that patients continue to be isolated from others after they had left the hospital.

Table 1. Effective doses (EF) to family members of thyroid cancer patients.

| No. | EF (mSv) | Sex | Age (y) | No. | EF (mSv) | Sex | Age (y) |
|-----|----------|-----|---------|-------------|-------------|-----|---------|
| 1 | 0.05 | m | 28 | 16 | 0.40 | m | 40 |
| 2 | 0.00 | m | 35 | 17 | 0.51 | m | 70 |
| 3 | 0.00 | m | 26 | 18 | 0.08 | m | 40 |
| 4 | 0.27 | f | 38 | 19 | 0.43 | m | 40 |
| 5 | 0.00 | m | 46 | 20 | 0.06 | m | 41 |
| 6 | 0.16 | m | 35 | 21 | 0.33 | f | 60 |
| 7 | 0.02 | f | 50 | 22 | 0.02 | m | 41 |
| 8 | 0.43 | m | 35 | 23 | 0.15 | m | 61 |
| 9 | 0.32 | f | 33 | 24 | 0.20 | m | 65 |
| 10 | 0.23 | f | 73 | 25 | 0.41 | m | 40 |
| 11 | 0.31 | m | 32 | 26 | 0.17 | m | 38 |
| 12 | 0.25 | m | 70 | 27 | 0.23 | m | 56 |
| 13 | 0.17 | f | 60 | 28 | 0.37 | m | 60 |
| 14 | 0.20 | m | 44 | 29 | 0.02 | m | 58 |
| 15 | 0.15 | m | 40 | 30 | 0.35 | m | 48 |
| | | | | Mean | 0.21 | | |

The mean value of the effective dose to relatives of thyroid cancer patients is 0.21 mSv. Figure 1 presents the effective doses to relatives of thyroid cancer patients versus proposed dose constraint of 3 mSv for adults and 15 mSv for older than 60 years of age according to the BSS. The family members' age varied from 28 years up to 73 years. The results show that the effective doses to all family

members were well below the recommended dose constraints of 1 mSv (recommended dose for children by the BSS).

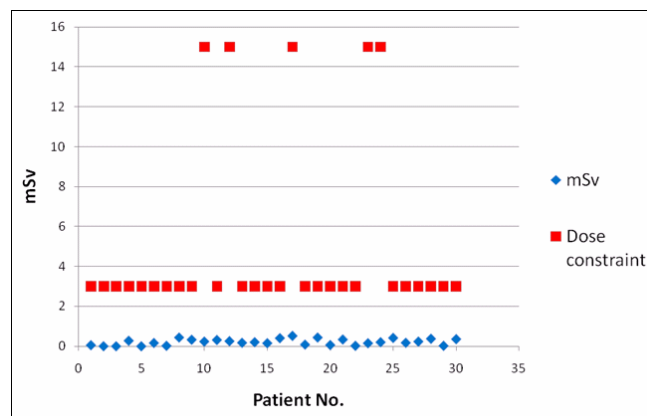


Figure 1. Effective doses to the relatives of thyroid cancer patients and the dose constraints of 3 mSv for adults and 15 mSv for older than 60 years of age, according to the BSS.

The results agreed with the previously published paper by Buchan *et al* [11] and proved that the protocol used for performing radioiodine therapy for thyroid cancer patient is sufficiently safe. Three days of hospitalization and dose rate measurements should be continued. It is recommended to ask patients to sleep alone for additional seven days and avoid close contact with other people, children and pregnant women [11]. Providing written instructions to patients about their behavior at home will improve the process of optimizing radiation protection to family members, public and environment. Mathieu *et al.* reported the dose to family members and children of thyroid cancer patients, and in all cases the measured doses were lower than 0.5 mSv [6].

4.2 Hyperthyroid patients

Table 2 presents the effective doses to relatives of the hyperthyroid patients treated with iodine-131 and measured with TLD dosimeters. Patient's relatives wore the TLDs for a period of one week. The mean value of the effective dose for the relatives of the hyperthyroid patients was 0.87 mSv. The range of the effective dose varied from 0.12 mSv to 6.79 mSv. For three patient spouses, the measured value was 0 mSv, and the explanation was that the patients stayed in different rooms and most of the times were away from home. The spouse of patient number 18 received the highest dose (6.79 mSv). The explanation was that the woman did not follow the given recommendation. She stayed very close to her husband all the time after he received his treatment. According to BSS, this 69-year-old woman was still below the 15 mSv allowed dose constraint. Further, eleven family members received effective doses higher than 1 mSv but less than 3 mSv (allowed dose constraint).

Figure 2 presents the values of all the hyperthyroid patients together with the dose constraint of the BSS. All values, except one, are below 3 mSv.

The statistical analysis showed significant difference between the relatives of thyroid cancer patients and hyperthyroid patients groups (Mann-Whitney U-Test $p < 0.001$).

The results of this study show that doses to the relatives of hyperthyroid patients are higher than the doses to the relatives of thyroid cancer patients. This observation is due to the lower retention and the faster wash-out of the iodine-131 activity from the body of the thyroid carcinoma patients, in spite of the higher administered activity.

Furthermore, the thyroid cancer patients after the administration of the radioiodine were hospitalized for three days in an isolated room. Another reason is that thyroid cancer patients retain less iodine as a result of the minimal thyroid tissue left after surgery. On the other hand, hyperthyroid patients were administered with fewer doses but were treated on an outpatient basis.

Table 2. Effective doses (EF) to family members of hyperthyroid patients.

| No. | EF (mSv) | Sex | Age (y) | No. | EF (mSv) | Sex | Age (y) |
|-------------|----------|-----|---------|-------------|----------|-----|---------|
| 1 | 1.25 | m | 63 | 16 | 1.90 | m | 55 |
| 2 | 0.00 | m | 40 | 17 | 0.33 | f | 52 |
| 3 | 0.00 | m | 29 | 18 | 6.79 | f | 69 |
| 4 | 0.78 | f | 44 | 19 | 0.21 | m | 56 |
| 5 | 0.23 | m | 45 | 20 | 1.23 | m | 66 |
| 6 | 0.52 | m | 41 | 21 | 0.38 | f | 33 |
| 7 | 0.23 | m | 52 | 22 | 0.40 | f | 44 |
| 8 | 0.12 | m | 39 | 23 | 0.21 | m | 57 |
| 9 | 1.2 | f | 44 | 24 | 0.00 | m | 40 |
| 10 | 1.14 | m | 58 | 25 | 0.51 | f | 43 |
| 11 | 0.52 | m | 80 | 26 | 1.25 | f | 57 |
| 12 | 0.54 | m | 40 | 27 | 1.48 | f | 50 |
| 13 | 0.17 | m | 32 | 28 | 1.32 | f | 42 |
| 14 | 0.16 | m | 56 | 29 | 1.70 | f | 47 |
| 15 | 0.48 | m | 70 | 30 | 1.17 | f | 60 |
| Mean | | | | 0.87 | | | |

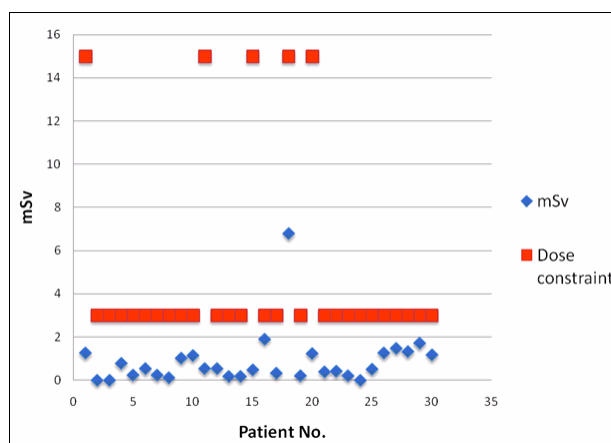


Figure 2. Effective doses to the relatives of hyperthyroid patients and the dose constraints of 3 mSv for adults and 15 mSv for older than 60 years of age, according to the BSS.

The oral and written instructions were the same, for both hyperthyroid and thyroid cancer patients. The restriction time is different (seven days for thyroid cancer patients and three days for hyperthyroid patients), and this information is usually given verbally by the physicians. Although the radiation doses to hyperthyroid family members are within the recommended limits, the values are higher in comparison with the doses of the family members of thyroid cancer patients. The higher doses to the relatives of the hyperthyroid patients are also due to the higher radioiodine retention of the thyroid gland and, thus, higher doses to the patients [6].

5. Conclusion

The radiation doses to family members of patients treated with radioiodine-131 for thyroid cancer were found to be well below the proposed dose limit of 1 mSv. Thyroid cancer patients should continue to be treated with the same way, so as patients after three days of hospitalization not to

present any radiation hazard to their family members.

The effective doses of eleven family members of hyperthyroid patients were higher than 1 mSv, whereas one person received 6.79 mSv. It is necessary to formulate new instructions for hyperthyroid out-patients after treatment with radioiodine-131 to comply with the requirements of the revised ICRP limits.

This study has provided useful information on radiation protection and exposure to family members of patients with thyroid carcinoma and hyperthyroid, treated with radioiodine-131.

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