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Dosimetric evaluation in the thyroid region of individuals occupationally exposed during the liberation of the iodotherapy room

Filipov[a] D., Barbosa[a] M., Dias[a] C.R.B.R., Colaço[b] I.M.

[a] *Universidade Tecnológica Federal do Paraná, Av. Sete de Setembro, 3165 - Rebouças, Curitiba - PR, 80230-901*
e-mail:dfilipov@utfpr.edu.br

[b] *Quanta Diagnóstico por Imagem, R. Almirante Tamandaré, 1000 - Alto da XV, Curitiba - PR, 80045-170*
isy@quantamn.com.br

ABSTRACT

Iodotherapy is a complementary treatment to surgical thyroid resection, being performed with radioactive iodine (^{131}I). To undergo the treatment, the patient must be hospitalized due to the exposure of other people to the ionizing radiation emitted by the radiopharmaceutical. The patient's hospitalization time, which could range from one to two days, is dependent on the activity of the radioactive material administered. After the patient´s discharge from the hospital, another one may be hospitalized; however, the room must be monitored by the technical staff in order to verify whether there is radioactive contamination from the previous patient. Therefore, the present study aims to verify the dose received in the staff´s thyroid region during the monitoring of the therapeutic room after discharge, since the thyroid is one of the most sensitive to iodine. Two occupationally-exposed members of staff (called "V1" and "V2") were monitored using TLDs positioned in the thyroid region. V1 and V2 were monitored for 7 months and 3 months, respectively, according to the workflow of the clinic where the study was performed. With the doses received, during these periods, it was estimated that the annual doses received by V1 and V2 were (11.2 ± 5.2) mSv and (12.7 ± 1.0) mSv, respectively. These results are below the dose limits established by the ICRP and other international guidelines, which reveals that the research clinic is concerned with occupational radiation protection, and no other radiological protection actions, based on the thyroid exposure, are necessary.

Keywords: Occupational Dose, Iodotherapy, Nuclear Medicine.

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1. INTRODUCTION

One of the main characteristics of nuclear medicine (NM) is the use of radiopharmaceuticals as a diagnostic and therapeutic tool. However, the application of radiopharmaceuticals leads to other variances, such as exposure to the patient, the staff, and the companions. In the present research, immunotherapy will be approached, which is used in NM as the therapeutic objective of destroying the remaining cancer cells after thyroidectomy. For this therapy, ^{131}Iodine is used because thyroid tissue is the only tissue in the body that absorbs and maintains iodine [1].

^{131}Iodine therapy basically consists of the administration of ^{131}I; as a consequence, the patient remains isolated in the therapeutic room until the exposure rate is within the acceptable limit of release. During the period of hospitalization, although the place is covered using a plastic film to avoid direct contact with objects and the professionals are trained, they still get contaminated. Also, in order for the next hospitalized patient not to be exposed to excessive radiation, the room should be cleaned. When the patient is discharged from the hospital, the room needs to be inspected for the presence of contamination of radioactive material (patient's own waste) so that the next patient is not subjected to an unnecessary dose. This stage of the inspection is performed by a technical team (biomedical and/or technologists) [1].

According to Hironaka and collaborators, the need for shielding always depends on attenuation calculations. It is known, for example, that the lead coat reduces by less than 13% of the exposure to the 364 keV photons of ^{131}Iodine, and that by reducing the agility of the professional can increase the exposure time, thus not having the benefit that you imagine. Based on this information, the occupationally exposed individual (OEI), during the release procedure of the hospitalization room, does not use protective clothing and experiences a certain level of exposure to ^{131}Iodine [2].

In the literature, there are few studies on occupational exposure in iodotherapy, and no study yet on occupational dose during the cleaning of the room [3, 4, 5]. Therefore, based on the previous data, the necessity of more studies in this area and the fact that there are limits of occupational equivalent doses (300 mSv/year according to the German Regulation on Radiation Protection [6] and 500 mSv/year according to ICRP [7]), it is necessary to evaluate the annual equivalent dose received by the thyroid of professionals who release the rooms from iodine therapy.

2. MATERIALS AND METHODS

The study was initially evaluated and approved by the Research Ethics Committee Involving Human Subjects of the Federal Technological University of Paraná. All study participants (volunteers) signed an informed consent form after understanding the aims of the study and the study procedure.

The included OEIs were determined according to the scale of work established. This was done voluntarily, by the clinic, without interference by the researchers. Their identification was kept confidential by using numbers instead of their names.

To obtain the doses, thermoluminescent dosimeters (TLDs) of LiF:Mg,Ti, in the form of round chips measuring 5 mm in diameter and 0.9 mm in thickness, packed in a radiotransparent material, from RadPro International GmbH (Wermelskirchen, Germany).

Previously, these dosimeters underwent a calibration process at the Laboratory of Metrology of Ionizing Radiation at the Federal University of Pernambuco. In this process, the TLDs were irradiated by a source of ^{137}Cs, in pairs, to a depth of 0.07 mm in an acrylic phantom and at a distance of 150 cm from the source, with known doses of 2 mSv, 4 mSv, and 8 mSv. A pair of TLDs remained on the outer side of the room to account for background radiation (BG). With this calibration, the objective was to determine the Hp(0.07), which is the personal dose equivalent in the thyroid. The calibration factor obtained was 0.0017 ± 0.0001 mSv/counts.

After the calibration, the packs with two TLDs were positioned in the neck of the volunteers, in the region of the thyroid (Figure 1), at the beginning of the Iodotherapy room cleaning, where one patient was hospitalized. In the end, the packages were removed from the neck and stored in a place that was considered a free area until the next cleaning. The same pair of TLDs were used in the same volunteer for a whole month.

After this period, the readings of the TLDs were performed using dedicated equipment (Figure 2), which were responsible for heating the dosimeter. The readings were performed using a heat rate of 10ºC/s, from 100ºC to 400°C, and the measurement comprehended the area of the LiF:Mg,Ti TLD glow curve from 100ºC to 300 °C. At the end of each reading of the TLDs, they underwent heat treatment in order to eliminate any residual signal from the previous irradiation. At this stage, the dosimeters were placed in a ceramic vessel and annealed at a temperature of 400°C for 1 h, then cooled on a refractory surface to room temperature [8].

Figure 1: *TLD package positioned near the thyroid (on the neck) of the volunteer.*

Figure 2: *TLD reader RA'04 from RadPro International GmbH (Wermelskirchen, Germany).*

The study was carried out over a period of seven months, from September 2018 to March 2019. Two volunteers (V1 and V2) were evaluated, and V1 and V2, who were responsible for cleaning the rooms whose patients, received activities of 100 mCi and >150 mCi, respectively. V1 was monitored from September 2018 to November 2018, and V2 was monitored from September 2018 to March 2019.

In addition, a form was prepared so that during the monitoring, some parameters such as activity administered to the patient in the room, instruments used, the need to interrupt monitoring, and duration of the release of the room could be determined.

3. RESULTS AND DISCUSSION

Table 1 shows the Hp(0.07) received by the two professionals (V1 and V2) during the monitoring period and an annual estimate.

Table 1: Hp(0.07) in V1 and V2

Volunteer	Cumulative Hp(0.07), in mSv, during the monitoring period	Annual Hp(0.07), in mSv
V1	2.8 ± 1.6	11.2 ± 5.2
V2	7.4 ± 0.6	12.7 ± 1.0

For V1, Hp(0.07) in the thyroid, accumulated over a period of 3 months was 2.8 ± 1.6 mSv. For V2, the dose received by the thyroid region, accumulated over a period of 7 months, was 7.4 ± 0.6 mSv. In this table, it is also visualized that the annual equivalent doses in the thyroid region for V1 and V2 are (11.2 ± 5.2) mSv and (12.7 ± 1.0) mSv, respectively. The results show that V1 had lower doses than V2, possibly because V1 was responsible for the release of the rooms whose patients received activities of 150 mCi. In these situations, the release occurred only on the day after hospitalization, which allowed a considerable reduction in exposure to the professional. In addition, V1 performed fewer releases of the therapeutic room, because during the study, most hospitalizations occurred with patients receiving 100 mCi.

When comparing the results of the doses obtained in V1 and V2 with the ICRP and the German Regulation, which determine a dose limit of 500 mSv/year and 300 mSv/year, respectively, for the thyroid gland, it was observed that the annual doses for both professionals were well below the limits of regulatory standards. These results reveal that the research clinic is concerned with occupational radiation protection, and no other radiological protection actions, based on thyroid exposure, are necessary.

It is also noted from the data in Table 1 that the measurement uncertainties, especially in volunteer 1, were approximately 50% to 60% (different from 8% of the uncertainty found in V2 measurements). This may have been caused by the fact that V1 was monitored for 3 months only, compared to 7 months of V2 monitoring. During this period, V1 performed less cleaning of the inpatient rooms and, consequently, was exposed to less radiation. As a result, the dosimeters might have been poorly sensitized, generating information with a higher margin of error.

It was also verified that there are few studies on occupational exposure in iodotherapy and no study on occupational dose during the cleaning of the room. One of the studies revealed a low level recorded: an effective dose of 1.5 mSv/year [3]. In another study, the dose absorbed by the thyroid gland in a worker who delivered a radioactive dose of ^{131}Iodine to the patient was below the stipulated limits, and as such, did not present considerable values of level of radiation [4].

Calegaro and Teixeira evaluated the occupational doses of nursing professionals for 11 years to assist the iodotherapy procedure. The annual effective doses, verified in the chest region, were 0.35 mSv and 2.30 mSv [5]. The cleaning room procedure is longer than the administration of ^{131}I to the patient, which may explain the higher annual Hp(0.07) obtained in the present study, in comparison with the literature.

With the applied form, it was found that both volunteers used gloves (avoiding contamination of the hands) and disposable linen, econtaminating materials, and plastic bags during the release of the therapeutic room. It was verified that there was no interruption of the monitors when they started, neither was there the use of plumbiferous accessories since the main form of interaction of radionuclide gamma radiation (which may have up to 637 keV of energy) with the atoms in the apron is the Compton effect [9]. This interaction has, as a consequence, the generation of scattered radiation, which can end up affecting the skin of the professionals, increasing their exposure. In this case, the clinic recommends to its staff to do the work in the shortest possible time and to not use the lead apron.

Therefore, the dosimetric analysis in this region is of fundamental importance due to the fact that professionals are subject to other radioactive sources. It is recommended that this dosimetry be performed by other service professionals (technologists, pharmacists, and/or biomedical), so that the thyroid doses of these other OEIs are also lower than the limits.

4. CONCLUSIONS

Based on what was presented, the objectives initially proposed were to estimate the annual dose received in the thyroid region of professionals during the release of the iodine therapy room.

When comparing the results of the doses obtained in volunteers 1 and 2 with some international regulations, which determine a dose limit from 300 mSv/year to 500 mSv/year for the thyroid gland, it was observed that the annual doses in both professionals were well below the limits (approximately 96.9% lower than the limits).

Therefore, it is fundamental to measure doses in this region, since these professionals are exposed to other radioactive sources, and the authors recommend that this dosimetry be performed by other service staff (technologists, pharmacists, and/or biomedical).

The authors also suggest that more studies be conducted in this area in order to correlate results from different sites with a larger number of professionals involved since there are few studies on occupational exposure in iodotherapy, and no study on occupational dose during the cleaning of the room.

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