

Dosimetric analysis of persons accompanying nuclear medicine patients in the therapeutic room*

Análise dosimétrica de acompanhantes de pacientes de medicina nuclear internados em quarto terapêutico

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Abstract **OBJECTIVE:** The present study evaluated the doses received by companions who had shared therapeutic rooms with patients undergoing treatment with 131-iodine (¹³¹I). The results were compared with the limits established by the Brazilian radiation protection regulatory standard. **MATERIALS AND METHODS:** Six pairs of persons (a patient and a companion sharing a same therapeutic room) were evaluated. Still, other 23 experiments were accomplished with a phantom replacing the companion. The therapeutic ¹³¹I activities given to the patients corresponded to 3700 MBq or 5550 MBq. Powdered lithium fluoride thermoluminescent dosimeters doped with magnesium, titanium and sodium were utilized for evaluating the doses. **RESULTS:** The results demonstrate that a person sharing a same therapeutic room, for two days, with a patient who had been given 3700 MBq or 5550 MBq of ¹³¹I, according to radioprotection recommendations, is exposed to a mean dose of (0.51 ± 0.02) mSv for a 99% confidence level. **CONCLUSION:** According to the Brazilian radiation protection standards there is no impediment for a person to accompany a nuclear medicine patient who has been given 3700 MBq or 5550 MBq of ¹³¹I during the patient stay in the therapeutic room.

Keywords: Nuclear medicine; Companion; Therapeutic room; Thermoluminescent dosimeter.

Resumo **OBJETIVO:** Este trabalho avaliou doses recebidas por acompanhantes que compartilharam o mesmo quarto terapêutico com pacientes tratados com câncer de tireóide ingerindo iodo-131 (¹³¹I) e comparou os resultados obtidos aos limites determinados pelas normas brasileiras de radioproteção. **MATERIAIS E MÉTODOS:** Avaliaram-se seis grupos de pessoas. Cada grupo foi formado por um acompanhante e um paciente, que compartilharam o mesmo quarto terapêutico. Realizaram-se, também, 23 outros experimentos, sendo que nestes um simulador foi usado em substituição à segunda pessoa no quarto terapêutico. As atividades de ¹³¹I administradas aos pacientes foram de 3.700 MBq ou 5.550 MBq. Dosímetros termoluminescentes na forma de pó, fluoreto de lítio dopado com magnésio, titânio e sódio foram usados para a avaliação das doses. **RESULTADOS:** Os resultados mostraram que uma pessoa que compartilha o mesmo quarto terapêutico, durante dois dias, com um paciente tratado com 3.700 MBq ou 5.550 MBq de ¹³¹I, seguindo as orientações de radioproteção fornecidas pela equipe médica, é exposta a uma dose média de $(0,51 \pm 0,02)$ mSv, para um nível de confiança de 99%. **CONCLUSÃO:** De acordo com as normas brasileiras, do ponto de vista da radioproteção, não há impedimento acompanhar um paciente de medicina nuclear durante esse tratamento. *Unitermos:* Medicina nuclear; Acompanhante; Quarto terapêutico; Dosímetro termoluminescente.

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INTRODUCTION

Radiotherapy is based on the concept that iodine-131 (¹³¹I) is actively accumulated by a considerable part of a tumor and/or metastases originating from differentiated thyroid tumors, allowing the destruction or reduction of the tumor after receiving

high radiation doses. The major difficulties are in selecting the patients for the effectiveness of the treatment, and the type of radiological protection to be adopted.

A significant development has been observed in the field of radionuclide treatment in the last ten years, however, it is important to note that the therapy with radioactive iodine has been utilized since 1955⁽¹⁾.

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An example of nuclear medicine therapeutic procedure is the treatment of differentiated thyroid tumors (papillary and follicular). The rate of cure is high after radio-

therapy, with a disease-free survival of about 30 years. Even a patient affected by distant metastasis can keep the disease under long-term stable control⁽²⁾. However, ¹³¹I is a source of high energy gamma radiation, leading to exposure of the environment around the patient. Therefore, the patients must be treated as an in-patient, in an appropriate room and in compliance with the guidelines for radiation protection established by Comissão Nacional de Energia Nuclear (CNEN) (National Commission for Nuclear Energy)^(3,4). CNEN is a federal agency responsible for ensuring that facilities involved in the utilization of ionizing radiation operate in compliance with criteria and guidelines for radiation protection to guarantee that the radiation levels are as low as reasonably practicable aiming at minimizing the exposure to ionizing radiation of the population as a whole⁽⁵⁾.

The current criteria for isolation of nuclear medicine patients receiving therapeutic ¹³¹I doses of > 1,11 GBq require the admission of the patient to a hospital, in an individual therapeutic room. In case of necessity, two in-patients may be accommodated in a same therapeutic room, provided a mandatory protective barrier (lead-shielded screen) is placed between the beds. The therapeutic room, duly signalized and with controlled access, must have impermeable walls and floor to allow decontamination, rounded corners, private toilet and a lead-shielded screen beside the bed⁽³⁾.

The patients can be discharged as they present a ¹³¹I activity ≤ 1.11 GBq⁽³⁾, which corresponds to a radiation exposure rate of about 1.8 μC/kg, measured by a MIR series 7026 area monitor (Instituto de Engenharia Nuclear/CNEN), at a one-meter distance from the ¹³¹I source. The current legislation⁽⁴⁾ establishes restricted doses, so it is unlikely that companions receive > 5 mSv during the whole patients' treatment period.

Hypothyroidism and the isolation required for the treatment, most of times, result in significant psychological problems, so the procedure becomes extremely difficult for the patients. Many times, they cannot tolerate more than one hospital stay.

In the case of disabled, psychologically disturbed patients or children, the presence

of a companion is required, and both share the therapeutic room. Typically, the companion is a relative of the patient, and, preferably, he/she should not be in childbearing age or not intending to have a child. Both the patient and the companion are given instruction on radioprotection by the clinical staff, for example, the companion should approach the patient only as necessary to avoid unnecessary exposure to the ¹³¹I ionizing radiation present in the body of the patient.

In case of a patient with thyroid cancer treated with 5550 MBq ¹³¹I, Mathieu et al.⁽⁶⁾ report that the dose received by the companion for a 15-day period, after the patient is discharged, is on average 0.24 mSv. Coover et al.⁽⁷⁾ report that patients are discharged immediately after receiving ¹³¹I with activities > 7400 MBq. From the psychological point of view, this new routine has been of great benefit for patients, their families and friends, besides minimizing the exposure to ionizing radiation of the whole clinical team, and reducing the treatment costs because of the early patients' discharge.

The present study was aimed at evaluating the dose received during a two-day hospital stay by the companion of a patient submitted to treatment with ¹³¹I for thyroid cancer, considering that the companion and the patient share a same therapeutic room, and comparing the results obtained with the dose thresholds determined by the Brazilian radiological protection standards^(3,4). The radiation dose was evaluated with the aid of a thermoluminescent dosimeter.

MATERIALS AND METHODS

The primary objective of the present study was not evaluating a possible contamination of the companion, for example, by ¹³¹I inhalation, or skin contact with this radionuclide, but only evaluating the dose received by the companion because of the exposure to the radiation originating from the patient.

Two experiments were developed to evaluate the received-doses in nuclear medicine patients' companions. In the first experiment, the companions were monitored with a thermoluminescent dosimeter, and in the second experiment, an acrylic

phantom with the same type of dosimeter was utilized within the therapeutic room in the presence of the patient. The second experiment was adopted, considering that the presence of a companion is rare in these cases. This experiment allowed the obtention of a higher number of measurements, improving the statistical results accuracy. As the expected dose received by the companion was low, a single dosimeter was utilized for determining the mean dose for a determined administered ¹³¹I activity. Two of the most utilized ¹³¹I activities (3700 MBq and 5550 MBq) in Brazil were considered in the present study. The dose received by the companion of a patient who received a 3700 MBq activity could not be evaluated. However, all the doses involving this activity were obtained with the utilization of the phantom. Six companions of patients who had received 5550 MBq activities were monitored and the mean dose obtained in this situation corresponds to the quotient between the total integral dose (because of the six patients) and the number of patients. Ten patients were considered for both activities in the measurements with the phantom. Therefore, the values of mean doses for both 3700 MBq and 5550 MBq, correspond to the quotient between the total integral dose and the number of patients. All the measurements were performed with a lead-shielded screen placed between the beds of the patient and companion/phantom.

All the individuals involved in the experiment were given explanations about the objectives of the study as well as about the procedures performed. Both patients and companions signed a term of free and informed consent. Age, sex and presence of other diseases were not taken into consideration for the individuals selection. The present study was submitted to and approved by the Committee for Ethics in Research of the Institution where the experiments were developed.

The study presented a longitudinal character with a confidence level of 99% and three standard deviations. The experiment involved the evaluation of doses with thermoluminescent dosimeters.

The phantom utilized was a polymethyl methacrylate (acrylic) cylinder, with 0.4 cm-thick walls (diameter = 8.0 cm and

height = 13.0 cm) filled with water. Two thermoluminescent capsules were fixed to the cylinder surface with adhesive tape. The phantom remained on a bed at 2.85 m from the patient's bed during the whole treatment period (48 hours).

The thermoluminescent powder utilized was lithium fluoride doped with magnesium, titanium and sodium (LiF:Mg,Ti,Na) produced by Philitech (France), under the code DTL937. This product is enriched with lithium-7 (⁷Li), and, considering the objectives of the present study, presents appropriate characteristics including low fading at ambient temperature (5%/year). The material regeneration was achieved by means of three-hour pre-irradiation thermal treatment at 450 °C. The post-irradiation treatment was performed in the thermoluminescent reader at 125 °C for five seconds. This temperature is lower than the one for evaluating the thermoluminescent dosimeters (440 °C). An ETT oven (Fimel, France) was utilized in the thermal treatment of the dosimeters. The irradiated thermoluminescent powder was evaluated in an automatic Fimel PCL3 reader with a RTC XP1122 model photomultiplier.

The thermoluminescent dosimeters were calibrated with the aid of a cobalt-60 source (⁶⁰Co). The mean energy of the photons emitted by ¹³¹I is 364 keV and, for this energy, the DTL937 response energy dependence is not significant and can be disregarded in the dose calculation. Therefore, the calibration factor obtained for the ⁶⁰Co gamma radiation energy can be utilized for determining the ¹³¹I doses without the necessity of additional correction.

The thermoluminescent powder was enclosed into sealed, 2.3 cm long cylindrical polyethylene capsules with (external diameter = 0.5 cm). A pair of these capsules was externally fixed with an adhesive bandage to the cloth of the companion at the level of the chest. This site was chosen to facilitate the procedure reproducibility. The dosimeters remained in place during the whole treatment period, except during the bath. A 2.0 cm-thick lead-shielded screen (length = 1.07 m × height = 1.06 m) was placed between the patient and companion/phantom beds.

At the end of the treatment, 48 hours after the iodine-131 ingestion by the pa-

tients, the dosimeters were removed from the companions clothes or phantoms for later analysis in the thermoluminescent dosimetry laboratory.

The present study was developed in compliance with the Brazilian radiological protection standards^(3,4). Additionally, the doses evaluated with the thermoluminescent dosimeters positioned on the phantom at 2.85 m from the patient were compared with the results of the calculation performed according to the procedures recommended by the North-American standards NRC-8.39 and 10CFR35.75^(8,9). In this case, the lead-shielded screen was not utilized between the phantom and the patient to reproduce the calculation conditions described in those standards^(8,9). Calculations and measurements were performed for a ¹³¹I activity = 5550 MBq (the most frequently utilized during treatments).

RESULTS

Table 1 demonstrates that the integration of the doses measured by a pair of thermoluminescent dosimeter fixed to a phantom which had been exposed to ten patients who had received 3700 MBq activities of ¹³¹I, for a two-day treatment period allowed the determination of a mean dose of (0.28 ± 0.01) mSv. When the same phantom was submitted with another pair of dosimeters to other ten patients who had received 5550 MBq activities of ¹³¹I for a 24-hour period, this dosimeters recorded a mean integral dose of (0.40 ± 0.02) mSv. Also, Table 1 shows that a same pair of thermoluminescent dosimeters recorded a mean integral dose of (0.51 ± 0.02) mSv, when fixed to the clothes of six persons accompanying patients who had ingested 5550 MBq activities of ¹³¹I, sharing a same therapeutic room for a two-day period.

The maximum dose calculated according to the North-American standards NRC-

8.39 and 10CFR35.75^(8,9), for a determined point at 2.85 m from a point source of 5550 MBq of ¹³¹I, is 0.42 mSv. The three values recorded by thermoluminescent dosimeters fixed to the phantom and placed at the same 2.85 m-distance from patients who had ingested the same activity of ¹³¹I (5550 MBq), where: (1.24 ± 0.09) mSv, (0.98 ± 0.07) mSv and (0.99 ± 0.07) mSv, corresponding to a mean value of (1.07 ± 0.13) mSv.

DISCUSSION

The difference observed between mean dose values found in the companions and in the phantom sharing a same therapeutic room with patients who received 5550 MBq of ¹³¹I, can be explained by the deambulation of the companion and consequential variation in distance of his/her dosimeter from the patient, while the dosimeters fixed on the phantom remain static on the other bed. As expected, the greater the administered ¹³¹I activity, the higher the dose recorded by the thermoluminescent dosimeter. It is important to emphasize that all the doses measured are below the radiation dose threshold established by the radioprotection standard NN-3.01⁽⁴⁾, corresponding to 5 mSv/year. Therefore, according to the mentioned standards, from the radiological protection point of view, there is no impediment to any person accompanying a patient under treatment with ¹³¹I for thyroid cancer, receiving activities ranging between 3700 MBq and 5550 MBq.

The fact that the dose measured in the phantom (1.08 ± 0.03) mSv was higher than the calculated dose (0.42 mSv) is explained by the fact that the source was not a point source, considering that the radionuclide is distributed throughout the body of the patient whose movements can reduce the 2.85 m-distance considered for calculation of the dose to the point source. It is important to emphasize that, even in the absence of the lead-shielded screen, both the measured and calculated values are below the 5 mSv threshold established both by the Brazilian^(3,4) and North-American standards^(8,9).

The results of the present study confirm that the radiation dose received by a companion sharing a same therapeutic room

Table 1 Mean doses received by companions of nuclear medicine patients under ¹³¹I therapy.

	Activities (MBq)	
	3700	5550
	Doses (mSv)	
Phantom	0.28 ± 0.01	0.40 ± 0.02
Companion	-	0.51 ± 0.02

with a nuclear medicine patient who has been given 3700 MBq or 5550 MBq of iodine-131 during a two-day period does not exceed (0.51 ± 0.02) mSv. Therefore, one can conclude that, under the radioprotection point of view, the dose received by such person is in compliance with the Brazilian standards^(3,4), establishing a radiation dose threshold of 5 mSv/year. These results are in agreement with the results reported by Mathieu et al.⁽⁶⁾, and Coover et al.⁽⁷⁾. Additionally, according to the results of the present study and those reported by Mathieu et al.⁽⁶⁾, the companion of a patient who received 5550 MBq of ¹³¹I will receive about 0.75 mSv over a 17-day period, corresponding to a two-day treatment period (0.51 mSv) plus 15 days following the patient discharge from the hospital (0.24 mSv).

Considering that the patient and his/her companion share a same therapeutic room for a two-day period, the companion contamination with ¹³¹I administered to the patient is natural. ¹³¹I is a volatile radionuclide which is released through the respiration, skin pores, saliva, feces and urine of the patient. However, as previously mentioned, the present study has not con-

templated the evaluation of the dose received by companions as a result of a possible contamination. Notwithstanding, the results obtained both for the companions (0.51 ± 0.02) mSv and for the phantom (0.40 ± 0.02) mSv do not seem to indicate a significant companions contamination, if this has really occurred.

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