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Contamination Tests After Radionuclide Therapy Applied to Thyroid and Prostate Cancer Patients

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ABSTRACT

Purpose: Radiation exposure and potential risks in nuclear medicine clinics are critical concerns for both patients undergoing treatment and the healthcare staff. This study aims to investigate the radiation risks for patients receiving radioactive iodine (131I) and 177Lu PSMA therapy during their isolation period in the hospital. Materials and Methods: In this study, contamination measurements were conducted in rooms of thyroid and prostate cancer patients treated with 131I and 177Lu PSMA in our Nuclear Medicine clinic. The tests performed on thyroid and prostate cancer patients were conducted in two phases: prior to and subsequent to the cleaning of the room, immediately following the patients' discharge. Findings: In the evaluation of sample counts, the average counts per minute (cpm) for 131I and 177Lu gamma counters were 217.6±136.7 cpm and 457.3±428.1 cpm, respectively. In the inhalation contamination test, discharge doses were <30 µSv/h, and the counts from Whatman-3 papers placed at the head of the beds before treatment were 129 cpm, 220 cpm, and 339.5 cpm. In the wipe test, the counts before room cleaning were 388.7±241.5; 292.7±308.8; 757.8±828.4; 12600±17272; 144.2±142; 1664.6±2534.8; 1247.7±1595.7; 21.6±17; and 500.5±197.2 cpm. The samples taken after room cleaning were 162±59.2; 232.2±133.7; 998.4±1418.6; 6216.6±13000; 299.2±708.6; 763.2±739.4; 508.2±239.5; 870.3±1314.6; and 843±601.2 cpm. The average counts for the measurements on staff shoe soles were 434.06±434.1 cpm. Conclusion: According to the measurement results, the radiation doses were within permissible limits, and no hazardous values were observed during and after isolation.

Keywords: *Iodine-131, 177Lu PSMA, Radiation contamination, Radiation exposure, Surface contamination*

INTRODUCTION

Radionuclide therapies for thyroid and prostate cancer patients are widely and successfully applied both in our country and around the world in nuclear medicine clinics. The goal is to minimize radiation exposure and increase treatment efficacy by using appropriate radiopharmaceuticals and patient-specific dosimetry. Radioactive iodine (131I) is not only used diagnostically in thyroid studies but also as the oldest radionuclide used in the treatment of thyrotoxicosis and thyroid cancer. This iodine isotope has a physical half-life of 8.0 days and emits β-particles with a most abundant energy of 0.6 MeV and an average energy of 0.2 MeV, with a tissue range of 2.3 and 0.6 mm, respectively [1]. Radioactive iodine therapy is used for the ablation of residual thyroid tissue and metastases in other parts of the body, such as neck lymph nodes, after the surgical removal of the thyroid gland in thyroid cancer patients. Due to radiation safety, the application of doses exceeding 800 MBq requires hospitalization of the patient, with an average dose of 1.1-3.7 GBq typically administered [2]. Lutesium-177 is a radiopharmaceutical used in the treatment of neuroendocrine tumors and prostate cancer. In neuroendocrine tumors, it is used in the form of 177Lu DOTA-TATE, and in prostate cancer treatment, it is used as 177Lu PSMA. The half-life of 177Lu used for therapeutic purposes is 6.7 days, and for patients to be discharged, the amount of activity present in their bodies must decrease to 1400 MBq [3]. Informing patients and their relatives about contamination, the precautions to be taken, and the process before treatment is mandatory and necessary in clinics. Patients can be discharged after radionuclide therapy, provided that the detected dose rate at a distance of one meter from the patient does not exceed 30 µSv/hour. Generally, 75% of the administered activity is excreted within the first 24 hours after dose administration. During the isolation period, radiation contamination is expected from the patient's urine, sweat, and saliva [4].

In nuclear medicine, inhalation and contamination tests are conducted immediately after patient discharge and after room cleaning during the isolation period following radionuclide therapy. These tests help take precautions against potential radiation exposure and prevent possible risks. The tests particularly prefer patients receiving high-dose applications of radiopharmaceuticals that emit high-energy β and γ radiation and have long half-lives. 131I and 177Lu are two radiopharmaceuticals with have these characteristics. In nuclear medicine clinics, cleaning procedures are carried out in the rooms of patients who have received high-dose treatments after their discharge. During these procedures, cleaning staff and other hospital personnel, such as nurses, are exposed to specific doses of radiation. Additionally, it is crucial for patients to use rooms that are free from radioactive contamination. The aim of this study is to measure the contamination levels in the rooms of patients with thyroid and prostate cancer who have undergone 131I and 177Lu treatments in our clinic, and to assess the potential doses received by the staff.

METHODS

In this study, contamination measurements of rooms were conducted for thyroid and prostate cancer patients treated with 131I and 177Lu PSMA at the treatment unit of the Department of Nuclear Medicine, Istanbul University-Cerrahpaşa Medical Faculty. Measurements were taken in two stages: before and after cleaning the rooms, following the discharge of the patients. All tests followed the same procedure for both thyroid and prostate cancer patients. However, the measurements were conducted in different patient rooms. Whatman-3 papers, which are commonly used in contamination studies for their effectiveness in capturing particles on contacted surfaces, were used to collect samples from the rooms. The samples were counted using a CRC-25W model gamma counter from Compening. Its ion chamber is a time-tested, high pressure well design capable of measuring a dose as high as 6 Ci (250 GBq) with high accuracy.

Patient Population

Of the eight patients treated, seven received 131I for thyroid cancer treatment, while one received 177Lu PSMA for prostate cancer treatment. Among the patients treated with 131I, five were female, and two were male. The average dose of radioactive iodine administered was 139.2±40 mCi. The 177Lu PSMA dose administered to the prostate cancer patient was 200 mCi.

1-Activity Conversions of Counts from Samples

The tests were conducted by taking measurements before and after cleaning the rooms following the patients' radionuclide therapy. Samples were collected using 10x10 cm Whatman-3 papers. Samples were taken from door handles, cabinets, beds, toilets, table surfaces, mobile phones, shoe soles, and floors in the patient rooms. The samples were placed in tubes and counted for one minute using a gamma counter. The obtained counts for 131I and 177Lu were converted according to the count-activity conversion procedure. (Tables 1,2)

For the count/activity conversions:

- A homogeneous mixture was prepared in 1000 ml of water using 1 mCi of 131I and 177Lu radioisotopes for each radionuclide separately, and sampling was performed using pipettes to fill the tubes. The tubes were counted for one minute using a gamma counter.

- A linearity curve was drawn between count (cpm) and activity (mCi), and the corresponding activity units for all counts were obtained.

2-Inhalation Contamination Test

Considering the volatile nature of radioactive iodine, air contamination was tested. Two Whatman-3 papers were placed at the head of the bed before treatment and removed after the patient was discharged. Air contamination was measured from the particles collected on the paper during the hospital stay. The counts obtained from the gamma counter were recorded (Table 3). Based on the physical properties of 177Lu, samples for this test were taken only from the rooms of patients treated with 131I.

3-Wipe Test

The wipe test was conducted to assess contamination of the environment by radioactive substances. Samples were collected using Whatman-3 papers from door handles, beds, TV remotes, cabinet handles, toilet lids, faucets, and floor surfaces in the patient rooms. Samples were taken before and after cleaning the rooms, placed in test tubes, and counted for one minute using a gamma counter. The counts were recorded according to the sampled surfaces (Tables 4, 5).

4-Staff Shoe Sole Measurements

In nuclear medicine clinics, the active circulation of staff in controlled and supervised areas poses a risk of contamination. To evaluate this risk factor, random measurements were taken from the shoe soles of staff working in PET/CT, SPECT/CT, Thyroid Scintigraphy, and PET/MR, as well as from service nurses. The samples were counted for one minute using a gamma counter and recorded (Table 6).

RESULTS

1-Activity Conversions of Counts from Samples

After treatment, samples were collected from door handles, cabinets, beds, toilets, table surfaces, mobile phones, shoe soles, and floors in the patient rooms treated with 131I and 177Lu PSMA, respectively. The average gamma counter counts for the eight different surfaces were 217.6±136.7 cpm for I-131 and 457.3±428.1 cpm for 177Lu. The average activity conversions for these counts were calculated as 0.30±0.18 μCi for 131I and 1.34±1.14 μCi for 177Lu (Tables 1,2).

Table 1. Count-Activity Conversion of 131I Measured by the Gamma Counter

Count (cpm)	Activity (μCi)
452	0.62
444	0.61
185	0.26
172	0.24
167	0.23
131	0.18
99	0.14
91	0.13

Table 2. Count-Activity Conversion of 177Lu Measured by the Gamma Counter

Count (cpm)	Activity (μCi)
1384	4
823	2.4
336	1
250	0.75
229	0.69
227	0.68
224	0.68
186	0.56

2-Air Contamination Test

The treatment doses for patients receiving radioactive iodine therapy were 100 mCi and 150 mCi. Patients underwent isolation in Room 1 for one day, and in Rooms 2 and 3 for two days. The discharge doses were <30 μSv/h, and the counts read from Whatman-3 papers placed at the head of the beds before treatment were 129 cpm, 220 cpm, and 339.5 cpm.

Table 3. Counts of Samples Placed in Rooms

Room No.	Count (cpm)
1	129
2	220
3	339.5

3-Wipe Test

The counts from the sampled surfaces before cleaning the room were as follows: 388.7±241.5; 292.7±308.8; 757.8±828.4; 12600±17272; 144.2±142; 1664.6±2534.8; 1247.7±1595.7; 21.6±17; and 500.5±197.2 cpm (Table 4). After the room was cleaned, the counts for the samples were 162±59.2; 232.2±133.7; 998.4±1418.6; 6216.6±13000; 299.2±708.6; 763.2±739.4; 508.2±239.5; 870.3±1314.6; and 843±601.2 cpm (Table 5). The first seven numbered patients received 131I radionuclide therapy, while patient number 8 received 177Lu PSMA therapy.

Table 4. Count values (cpm) of samples taken before room cleaning

Sample Location / Patient No.	1	2	3	4	5	6	7	8
Door handle	90	194	648	753	251	389	569	216
Cabinet handle	35	44	568	138	551	828	98	80
TV remote control	108	98	1997	1770	327	X	64	941
Floor	1366	12470	46400	11170	1669	X	X	2526
Bed	364	26	150	350	8	70	33	153
Sink faucet	206	7838	1252	1324	678	774	115	1130
Toilet	280	3990	551	170	X	X	X	927
Room light switch	41	9	X	X	X	15	X	X
Sink light switch	640	361	X	X	X	X	X	X

Table 5. Count values (cpm) of samples taken after room cleaning

Sample Location / Patient No.	1	2	3	4	5	6	7	8
Door handle	219	197	259	118	91	126	114	172
Cabinet handle	140	148	131	304	399	452	112	172
TV remote control	530	292	413	4050	167	X	96	1441
Floor	993	580	32750	1262	985	X	X	730
Bed	1984	200	41	197	106	172	99	-405
Sink faucet	1746	1908	386	1156	472	274	45	119
Toilet	785	330	752	377	X	X	X	297
Room light switch	2387	168	X	X	X	56	X	X
Sink light switch	1268	418	X	X	X	X	X	X

4-Staff Shoe Sole Measurements

The average counts for shoe sole samples taken from two staff members working in PET/CT, SPECT/CT, Thyroid Scintigraphy, and PET/MR, as well as two service nurses, were 434.06±434.1 cpm. Changes in the counts, along with the type of radiopharmaceuticals used, the number of patients, and active circulation parameters in the areas, were within the expected limits.

Table 6. Counts of Samples Taken from the Shoe Soles of Clinic Staff

Staff No.	Count (cpm)
1	1658
2	732
3	654
4	561
5	439
6	358
7	291
8	258
9	126
10	66
11	57
12	10

DISCUSSION

Radiation contamination is a significant concern for both healthcare workers and patients in nuclear medicine clinics. This study investigated the amount of radiation disseminated into the environment during the isolation periods of patients undergoing 131I radioactive iodine therapy for thyroid cancer and 177Lu PSMA therapy for prostate cancer through various tests. The study not only assessed surfaces contacted by patients within their rooms but also evaluated the contamination risks to hospital staff. Tests conducted in patient rooms highlighted the importance of thorough room decontamination by collecting samples before and after cleaning. Willegaignon J. et al. examined the radiation potentials and surface contamination of patients treated with up to 7.4 GBq of radioactive iodine. The study found an average contamination level of 5.58 Bq/cm² on monitored surfaces. This research, which also considered solid waste, concluded that both staff and patient radiation doses were within acceptable limits and that the procedures were safely applicable. In our study, sample counts from staff shoe soles and

patient surface contamination indicated that all activities remained within safe limits [5]. Al Mohammed H. I. et al. evaluated radiation doses received by patients and staff in Saudi Arabia undergoing radioactive iodine therapy for thyroid cancer and hyperthyroidism. Measurements were taken from patients at various distances over a three-day period. The study involving 206 patients found that measurements in isolation rooms and corridors for thyroid cancer and hyperthyroidism were 0.2 mSv. The annual doses received by staff were calculated at 1.2 mSv. In our study, only thyroid cancer patients receiving 131I therapy were included in the contamination assessment. Samples taken from patient rooms after the isolation period and post-discharge were analyzed. Measurements of floor surfaces in all rooms, categorized before and after cleaning, showed an average reduction of 49.2% [6]. Shinkarev S. M. et al. investigated the impact of short-lived radioiodines on the thyroids of residents in the Fukushima area and neighboring regions following the Fukushima accident. This study examined the effects of inhalation, finding that the contribution of I-131 radioiodines during the primary fallout period was approximately 15%. In our study, pre-treatment samples collected from patient rooms were counted at 129 cpm, 220 cpm, and 339.5 cpm. The corresponding activity levels were 0.38 μCi, 0.66 μCi, and 1.02 μCi, respectively. The doses emitted by the three thyroid cancer patients treated with 100 mCi, 150 mCi, and 150 mCi of 131I via inhalation remained within the permissible limits [7].

CONCLUSION

As a result of the evaluation of sample counts, the activity accumulation in patient rooms with high doses was found to be higher compared to those with lower doses. According to the air contamination and wipe tests, patients with a two-day isolation period had higher contamination percentages compared to those with a one-day isolation period. Similarly, measurements of staff shoe soles indicate that dose values are higher in high-patient-density areas such as PET/CT and SPECT/CT. All counts were within permitted limits, and no data exceeding 1 mSv/h were detected. The 177Lu-PSMA samples were obtained from a single patient, and therefore, statistical evaluation is not possible. The 177Lu patient data presented in this study is intended as an example for future studies that could involve an expanded patient dataset.

Conflict of Interest

There are no conflicts of interest and no acknowledgements.

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