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A Retrospective Study for Total Effective Doses of Nuclear Medicine Employees in Istanbul, Turkey

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ABSTRACT

Thermoluminescence dosimeters (TLDs) are safely used to determine radiation doses. This study describes the radiation exposure doses of the radiation employees working at the Department of Nuclear Medicine, Cerrahpasa Medical Faculty in Turkey, where both radionuclide treatment and diagnostic imaging are done at a large scale. According to our results, the average effective dose value over five years belonging to an employee who works at radionuclide treatment service was found to have the highest value as 3.58±1.60 mSv. On the other hand, the average effective dose over a of total 29 employees is 1.53±0.59 mSv. A 5-year average effective dose was found as 1.29 mSv for technicians and 2.38 mSv for nurses. These results demonstrated that the radiation doses received by the employees working in different units are considerably different from each other. However, the doses received by all the workers in these units are under the regulatory limit. In conclusion, homogenized dose distribution between employees can be achieved in case of job rotations in-between.

Keywords: TLD dose, Dosimetry, Technician doses

Introduction

Dosimeters are used to determine radiation exposure dose of personnel working with ionizing radiation. The conditions of the appropriate usage, radiation dose limits and procedures to be followed in case of limits have been determined by the law. International regulations that govern basic principles for radiation protection and individual monitoring of exposed professionals are mandatory. The International Commission on Radiological Protection (ICRP; 103-2007) has established the following fundamental principles of radiation protection: justification (of medical exposure), optimization (of practices to reduce medical exposure) and application of dose limits (to prevent deterministic effect and reduce the probability of stochastic effects). The latest recommendations of the ICRP maintained the existing dose limits and, in addition, extended the concept of source-related constraint. National regulatory bodies must incorporate the ICRP recommendations into their legislation and implement them in clinical setting [1].

Recently, thermoluminescence dosimeters (TLD) have great utility towards determination of radiation doses. In our country, the evaluation of dosimeters is maintained by Turkish Atomic Energy Authority (TAEK), which is the national regulatory authority

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to ensure the safe use of ionizing radiation in all the radiation facilities all over Turkey. Dosimeters are sent to Çekmece Nuclear Research and Training Center, which is the division of TAEK, every three months and the doses are recorded in the archive. After that, the results of dosimeters monitored are sent back to relevant institutions and organizations.

ICRP recommends 20 mSv as an average dose over 5 years for each employee as the maximum accepted dose. However, a maximum 50 mSv dose is only allowed for a year once in 5 years' time period [2].

The principle, which recommends keeping exposed dose values at minimum, is known as ALARA (As Low As Reasonably Achievable) principle. Despite the radiation dose limit, the personnel are encouraged to practice ALARA in all aspects of radiation handling and in various applications [3].

Staff groups of different specialties contribute to the work in nuclear medicine, including technicians, pharmacists, radiographers, doctors, physicists, clinical scientists, administrative staff, nurses and laboratory technicians. Nuclear medicine technicians working with unsealed radiation sources are clinically exposed to radiation in the following ways: dispensing the radioactive material to the syringe, measuring within dose calibrator, during injection, during placement of patients for their having the scan and during disposal of radioactive waste material. Physicists are responsible for receiving and measuring the radionuclides, measurement of dose rate of patients and supervised areas, presenting dosimeter operations and management of radioactive waste. Radiopharmacists are responsible for milking Tc-99m and Ga-68 from the generator, labeling of radiopharmaceuticals with biologic agents and quality controls. Nuclear medicine nurse has a responsibility to follow the radionuclide treatment procedures. In addition, nurses perform several other tasks including inserting various lines and tubes as well as assessing the patients for tolerability of the procedures. Nuclear medicine technician must use shielded syringe during radiopharmaceutical injections and must wear lead gown during scanning of patients [4].

The aim of this study is to evaluate radiation exposure doses of nuclear medicine technicians and other employees working with ionizing radiation, at the Department of Nuclear Medicine in Cerrahpasa Medical Faculty, Istanbul University which has been one of the leading health care centers in Turkey.

Materials and Methods

This study was performed by evaluating TLD dosimeter measurements of employees working with ionizing radiation between the years of 2007-2011 at the Department of Nuclear Medicine in Cerrahpasa Medical Faculty, Istanbul, Turkey.

In this study, the dosimetric results of total 29 employees were evaluated. 15 of them were male and 14 of them were female. 16 of personnel were nuclear medicine technicians and 6 of them were nurses at radionuclide treatment service. Three of them worked as physicists and two of them worked as radiopharmacists. Two of them also worked as staff in charge of radioactive waste disposal. Sixteen nuclear medicine technicians working in radiation controlled areas were distributed in different locations as follows: four of them were at PET/CT scanning unit, two of them at whole-body bone scintigraphy scanning unit, two of them at nuclear cardiology scanning unit, two of them at nuclear endocrinology scanning unit, two of them at renal and GIS scanning unit, two of them at DEXA scanning unit, one of them at whole-body radioiodine scan unit within the radionuclide treatment service. One of them worked as the head technician.

All radiation employees in this department were educated on their own subjects and experienced in their duties. They have been receiving periodic trainings about radiation protection. In this way, the annual effective dose values could be limited to the minimum.

TLD measurements

When a TLD is exposed to ionizing radiation at ambient temperatures, the radiation interacts with the material and deposits into it all or part of the incident energy. Some of the atoms in the material that absorb that energy become ionized, producing free electrons and holes. Some of the charge gets trapped at defect sites. Thermal stimulation releases electrons which recombine with a luminescence center giving rise to luminescence. The process is so called thermoluminescence. Released light is collected and counted using photomultiplier tubes and the number of photons counted is proportional to the quantity of radiation.

Whole-body doses received by the employees were determined by badge dosimeters - three cylindrical TLD placed 2 cm apart from each other in the same plastic box (size of 5 × 5 × 2 cm3). The TLDs were fixed on the upper left side of body under the apron. The aprons used in our clinic have a 0.5 mm lead equivalent shielding material. Dosimeters are sent to Turkish Atomic Energy Agency (TAEK), Çekmece Nuclear Research and Training Center which has its headquarter in Ankara. After that, doses received by TLDs were read using a thermoluminescence reader (Harshaw 4500) in this center and the accuracy is given in ±5% limits.

Results

The effective doses accumulated over five years for the technicians, nurses, physicists, radiopharmacists and staff working with ionizing radiation are given in Table 1. The latter table gives the doses received by seventeen people who were exposed to radiation over five years, two persons over four years, five people exposed over three years, two people exposed over two years and finally three people after one year of exposure.

The highest annual average effective dose value of 3.58±1.60 mSv belongs to the employee number 21, who was working at the radionuclide treatment service (see Table 1)

The employee number 12 works at DEXA (Dual Energy X-ray Emission) had the lowest annual average effective dose of 0.43±0.15 mSv.

Statistical analysis was performed using the dedicated software tool SPSS 21:00. For the statistical evaluations, the doses received by technicians and nurses were compared using the Mann Whitney-U Test. For significance limit, $p<0.05$ is received. A highly significant difference between the nurses and technicians doses in 2009 ($p=0.005$) was revealed. For the years 2010 and 2011, there were significant differences between doses ($p=0.095$, $p=0.045$). For the case of nurses, dose values received are getting significantly higher for each year.

The average effective doses that nuclear medicine technologists were exposed to, while working in different scanning units are given in Figure 1. Values in the figure are annual average dose values of technologists working in the same scanning unit.

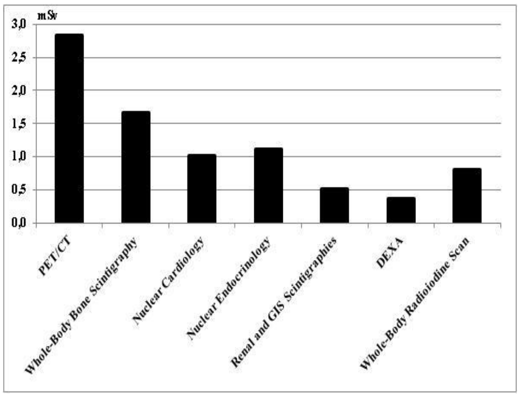

Fig. 1 *Annual average doses that technologists exposed to at different scanning units (mSv).*

According to Fig. 1, effective dose values were found to be the highest for technicians working at PET/CT and the lowest for technicians working at DEXA. The annual average effective dose distributions determined were found to be homogeneous among the examined sub-groups. Effective dose values over 5-years were found as 1.33±0.67 mSv for technicians and 2.38±0.4 mSv for nurses.

According to the data, while annual average dose for the case of a technician who worked for 3 years in the whole-body bone scintigraphy unit was 0.75 mSv; annual average dose of the same technician working for 2 years for PET/CT unit was found to be 3.58 mSv. Similarly, annual average dose for the case of a technician who worked for 4 years in renal and GIS scintigraphy unit was 0.54 mSv. But the annual average dose of the same technician working for one year in cardiac scintigraphy unit was found to be 0.90 mSv. Depending on factors such as the patient dose or concentration used, the difference of the dose taken when working in different regions clearly shows our results.

Effective dose values received by nuclear medicine technicians who work at different countries are given in Table 2. Annual effective dose values which were obtained in a single medical center in this study is noticed to be lower than the doses reported in other countries as shown in table 2 (Refs 6 and 7 indicate values belonging to all nuclear medicine technicians in their countries and Ref 5 indicates values for a single center). The average exposed dose values of 16 technicians who are working in different units of our department were consistent with the dose values of the technicians from other countries.

Table 2. *Average annual effective dose values belong to nuclear medicine technicians working in different countries.*

References	Country	Period	Annual Effective Dose (mSv)
Ref. 5	USA	2000	3.0
Ref. 6	Portugal	1999-2003	2.95
Ref. 7	Lithuania	1991-2003	2.12
This Study	Turkey	2007-2011	1.29

Table 1. *Accumulated dose distribution values for the employees of Department of Nuclear Medicine, Istanbul University per year*

Employee Number	**2007** Total Dose (mSv)	**2008** Total Dose (mSv)	**2009** Total Dose (mSv)	**2010** Total Dose (mSv)	**2011** Total Dose (mSv)	Total Dose (mSv)	Annual Average Dose (mSv)
1	1.87	0.42	0.65	0.54	0.54	4.02	0.80±0.27
2	0.64	0.27	0.45	0.80	0.73	2.89	0.58±0.10
3	1.63	0.27	1.14	0.55	0.54	4.13	0.83±0.25
4	0.74	0.27	1.24	4.76	2.39	9.40	1.88±0.80
5	2.33	1.80	1.80	3.03	3.23	12.19	2.44±0.30
6	1.18	0.74	2.57	0.55	0.54	5.58	1.12±0.38
7	0.57	0.28	3.24	1.19	0.54	5.82	1.16±0.54
8	3.32	1.39	1.18	3.43	1.57	10.89	2.18±0.49
9	0.63	0.27	1.02	0.54	0.54	3.00	0.60±0.12
10	0.78	0.27	1.47	1.30	1.86	5.68	1.14±0.28
11	1.02	1.49	2.30	2.56	1.21	8.58	1.72±0.30
12	-	0.18	0.46	0.55	0.54	1.73	0.43±0.09
13	-	1.72	1.02	0.98	0.54	4.26	1.07±0.24
14	-	-	1.32	4.17	3.83	9.32	3.11±0.90
15	-	-	0.45	1.02	0.54	2.01	0.67±0.18
16	-	-	-	0.8	1.04	1.84	0.92±0.12
Technician						**Mean**	**1.29±0.35**
17	0.91	1.14	2.83	2.02	0.65	7.55	1.51±0.40
18	1.76	2.09	2.87	2.23	0.72	9.67	1.93±0.35
19	2.59	2.70	3.38	2.70	1.86	13.23	2.65±0.24
20	-	-	2.39	2.41	2.42	7.22	2.41±0.01
21	-	-	5.08	4.31	1.36	10.75	3.58±1.13
22	-	-	1.26	3.06	2.23	6.55	2.18±0.52
Nurse						**Mean**	**2.38±0.44**
23	2.15	1.94	2.34	0.54	0.78	7.75	1.55±0.37
24	0.76	0.49	0.60	0.54	0.54	2.93	0.59±0.05
25	-	-	-	-	0.46	0.46	0.46±0.00
Physicist						**Mean**	**0.87±0.14**
26	-	-	-	0.23	1.08	1.31	0.66±0.43
27	-	-	-	-	0.69	0.69	0.69±0.00
Pharmacist						**Mean**	**0.67±0.21**
28	0.46	0.90	4.59	3.62	1.87	11.44	2.29±0.79
29	-	-	-	-	3.24	3.24	3.24±0.00
Staff						**Mean**	**2.76±0.40**
Average	-	-	-	-			**1.53±0.68**

Effective dose values of nuclear medicine technicians who work in different countries are given in Table 2. Doses of this study are lower than the reported in the other countries, because annual effective dose values were obtained in a single medical center. Ref. 6 and 7 indicate values belong to all nuclear medicine technicians in their countries and Ref. 5 indicates values for a single center.

In the USA, (states as Washington DC, LA, NC, FL etc.) nuclear medicine technologists generally work 40-hour a week. Opportunities for part-time and shift work are also available. Neves et al. [8] reported in 2012 that the number of nuclear medicine technologists was increasing (30%) in Portugal. 50.0% of technicians reported working more than 40 h/week, 46.3% reported working less than 40 h/week and 3.7% worked more than 60 h/week. In our country, nuclear medicine technicians work 40 h per week. As you noticed that it is generally similar to the working hours of different countries by reason of atomic energy authorities of the countries apply the recommendations of the IAEA. The average effective dose values of 16 technicians in our department are consistent with the dose values of the technicians from other countries.

Discussion

In our previous study [9], we had estimated absorbed dose values over 6 months of exposure for the case of technicians who worked in PET/CT unit with TLD dosimeters. We reported that annual absorbed dose was 5.76 mSv by extrapolation. In the current study, annual effective doses have been found to be 2.14 mSv for the same PET/CT technologists. The reason for the difference in dose values might be due to better statistics, as average dose values for five years are reported in this study and can be interpreted as increased experience of the employees.

There are also other publications reporting exposure doses for the employees working in the department of nuclear medicine and determining external dose rate measurements. For instance, Chiesa et al [10], reported 1 μSv of effective dose for myocardial perfusion, while whole-body bone scintigraphy was 0.3 μSv, and 0.18 μSv for thyroid scintigraphy taking into consideration PET/CT applications were not included. In a similar study, [11] also based on external dose rate measurements, the effective doses for myocardial perfusion, whole-body bone scintigraphy and thyroid scintigraphy were 1 μSv, 0.6 μSv, 0.3 μSv respectively. In another study [12], effective dose results for all the steps of bone scintigraphy process was 1.3 μSv, and 1.1 μSv for myocardial perfusion scintigraphy. The present study demonstrated that effective dose for the personnel in PET/CT control room was 2.27 μSv, for bone scintigraphy 0.69 μSv, and for myocardial perfusion scintigraphy 0.78 μSv. Our findings showed some differences in comparison to the mentioned studies above because of the effective doses of this study were determined by the TLD dosimeters in a relatively long period of 3-5 years.

Another related study conducted by TAEK [13] reported that the highest annual average effective dose in the medical applications was 0.29 mSv for nuclear medicine workers. Since there was no PET/CT system in our country until 2003, thereby PET/CT diagnosis absorbed dose has not been evaluated. In our study high result of 1.53 mSv may be due to the presence of PET/CT facility and treatment service.

Conclusion

Data of employees working in the Department of Nuclear Medicine at Istanbul University were observed to get different effective doses in different units. These average effective dose values remained fairly below the internationally set limits. However, limits can be assured to remain well below the acceptable values by incorporating the mechanism of job rotations.

Conflicts of Interest

The authors have no conflict of interest.

Acknowledgement

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References

[1] ICRP Publication 103. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP 37, 2-4 (2007).

[2] Draft Report for Consultation. ICRP Ref 4834-1783-0153,16-18 (2011).

[3] NRC Regulatory Guide 8.10, Revision 1-R (1975).

[4] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Report to the General Assembly. Vol. I Annex B 304–306 (2008).

[5] Thompson M.A., ‘‘Maintaining a proper perspective of risk associated with radiation

exposure''. J. Nucl. Med. Tech. 29, 137–142 (2001).

[6] Martins M.B., Alves J.G., Abrantes J.N., Roda A.R., ''Occupational exposure in nuclear medicine in Portugal in the 1999–2003 period'', Radiat. Prot. Dosim. 125, 130–134 (2007).

[7] Valuckas K., Atkocius V., Samerdokiene V., ''Occupational exposure of medical radiation workers in Lithuania, 1991–2003'', Acta Medica Lituanica 14, 155–159 (2007).

[8] Neves D., Valeb F.F., Pascoal A. ''The profile and practice of nuclear medicine technologists in Portugal: findings from a nationwide survey'', Nucl. Med. Commun. 33, 1277-1286 (2012).