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Personal Radiation Doses Monitoring For Nuclear Medicine Technology Students.

Saad, I[1,2]. Mosaad, M[1]. Qasem, H[1]. Tantawy, H[1]. Ibrahim, H[1].

[1]Department of Nuclear Medicine Technology, Inaya Medical College, Riyadh, KSA.

[2]Department of Clinical Oncology and Nuclear Medicine, Faculty of Medicine, Cairo University, Egypt.

ABSTRACT:

Nuclear medicine personnel exposed occupationally to ionizing radiation from radioisotopes during preparation, administration, and patients imaging. ICRP recommended that the main aim of radiation protection is about the protection of workers, trainees, and the public from radiation hazards. The effective dose or the equivalent dose must be assessed based on measurable or calculated quantities. The deep and shallow doses are used to evaluate the effective and equivalent dose to the person exposed to external radiation. Noting that Hp (0.07) is observed as equal to Hp (10) by the gamma-rays. The study aims to assess the radiation exposure incurred by undergraduate nuclear medicine technology students during the study period using an optically stimulated dosimeter. **Materials and Methods**: Radiation doses were monitored for 173 nuclear medicine technology students over four consequent years at Inaya Medical Colleges (Riyadh, KSA). Student dose equivalent was measured in terms of Hp $_{(10)}$ deep dose and shallow dose Hp $_{(0.07)}$, using calibrated optical stimulating-luminescent dosimeters (OSL), (Al_2O_3:C). These badges were read using an automatic OSL reader. **Results**; show that the mean deep dose OSL measurements were 0.844± 0.297, with a range from 0.24 to 1.4 mSv/y. As regards the shallow dose OSL measurements, the mean dose was (0.839 ± 0.297), the minimum reading was (0.24 mSv/y) and the maximum was (1.39 mSv/y).

Conclusion: All nuclear medicine technology students received radiation equivalent doses significantly lower than the ICRP dose limits during their training practice in their study period. The study denotes a safe training environment for students and proper understanding and application of safety procedures given to the students during their theoretical study courses.

Key Words: OSL dosimeters, Radiation Monitoring, Student Exposure.

Corresponding Author: Saad, I. **E-mail**: *i_elsayed@inaya.edu.sa.*

INTRODUCTION:

Nuclear Medicine technology curriculum design should engage the students with different levels of learning methods, including traditional theoretical methods, practical in-house training, and hospital clinical training. The theoretical courses and practical training do not contribute to any radiation exposure for the students, as it stands for regular classes and laboratory simulation techniques. However, hospital clinical training is considered the primary source of radiation exposure to students. They practice handling the real radioactive materials besides the real patients' cases imaging practice in nuclear medicine departments [(1)].

Nuclear medicine personnel is exposed occupationally to ionizing radiation from radioisotopes during preparation, administration, and patients imaging such as traditional gamma camera imaging, the single-photon emission computed tomography imaging combined with computed tomography (SPECT-CT). Also, positron emission tomography combined with the computed tomography scanner (PET-CT) or (PET- MRI) is considered as a main source of exposure [(2)]. The continuous progress in nuclear medicine technology and radio pharmacy warrant more caution about the possible increase in occupational exposure to the workers.

At first, the introduction of hybrid modalities that uses 18F-fluorodeoxyglucose (^{18}F-FDG) by the annihilation of positron emission of 511 keV as an efficient radiotracer for different tumors imaging as well as neuroimaging [(3, 4)].

Also the growing number of PET/CT procedures (at some 21% annual increases) and its advantages over the older conventional techniques in tumor staging and management [(3, 5)].

According to the ALARA (As Low as Reasonably Achievable) principle, all exposures should be minimized, and all unnecessary exposures must be prevented.

Nuclear medicine personnel are exposed occupationally to ionizing radiation from radioisotopes during preparation, administration, and patients imaging. Minimizing the exposure time, utilization of shielding, and operating at an appropriate distance from the radioactive source are the basic practical ways of reducing exposures in Nuclear Medicine departments. This is especially true in therapeutic procedures, where relatively large amounts of radioactivity are handled [6, 7].

The international commission on radiological protection (ICRP) [8] recommends that the principal aims for radiation protection are about the protection of occupational, training students, and the public.

In order to measure the personal dose, both the deep and shallow doses should be measured. The deep Hp (10) and shallow doses Hp (0.07) are used to determine the effective dose for the person exposed to external radiation.

Noting that Hp (0.07) is observed as equal to Hp (10) by the gamma-rays [2, 3, 4.9 and 10].

Optically stimulated luminescent dosimeters, OSLs, are composed of aluminium oxide doped with carbon (Al2O3: C) contained in plastic disks. These disks are enclosed in a light-tight plastic holder. The (Al2O3: C) crystals release a luminescence usually of (420 nm) when illuminated with stimulation light of about (540 nm) when exposed to ionizing radiation store energy. The intensity of the luminescence is dependent on the absorbed dose by the crystals and the intensity of the stimulation light. OSLs are measured by a reader [11, 12].

Several studies have investigated the occupational exposure of nuclear medicine technologists, but up to our knowledge, no study has investigated the exposure to the students during their period of practical training in nuclear medicine departments [13, 14].

The study aims to assess the radiation exposure incurred by undergraduate nuclear medicine technology students during the period of study using an optically stimulated dosimeter.

MATERIALS AND METHODS:

Study population: The study population included nuclear medicine technology students at Inaya Medical College (Riyadh, Kingdom of Saudi Arabia) who underwent a radiation safety program to monitor their exposure to ionizing radiation during the entire period of the study program.

After receiving a proper theoretical basis for radiation protection through multiple theoretical courses, they receive the OSL badges at the beginning of the third year of their study program and remain until finishing their internship year.

The badges are replaced every three months to record each student's radiation exposure measurements according to the college's radiation safety program. The internal review board has approved the study proposal at Inaya Medical College.

Data Collection: The students receive the OSL badges at the start of their clinical training and continue using them during their internship period. The distribution of the students during the clinical settings is made to fulfill the accomplishment of different competencies predetermined within the study program plan.

The OSL badges are collected every three months duration and then the students receive a replacement badge to continue their radiation surveillance without interruption. A total of 173 readings for students in the Nuclear Medicine Program have been collected over four years duration of the study.

Data measurement tools: The OSL badges are made of aluminum oxide doped with carbon (AL_2O_3:C) detectors. All collected badges are then read by the OSL reader. The reader used for the measurements is (In Light Auto 200 Dosimetry Reader) Nagase Landauer, LTD., Japan. This reader is operated with a high-sensitivity photon counting system and dose calculation algorithm with speed for readout of 12-13 seconds and can accommodate four packaging magazines, 50 dosimeters each, 200 dosimeters per load [15].

Statistical Methods: The purpose of the current study was to gather data for meaningful information about the exposure of nuclear medicine technology students during their study program duration. The students receive their badges at the beginning of the third year of the study program when they start their hospital clinical training and last till the end of their internship year. The readings of Deep dose and Shallow dose were measured in mSv/ year.

Comparisons between Deep dose and Shallow dose were also made, and finally, the deep and shallow doses were compared in reference to the ICRP dose limits for workers engaged in radiation work and students, apprentices (over 16 but under 18 years of age who are under training in the radiation field) as shown in ***Table (1)***.

Based on the data collected, independent samples, Paired sample tests were conducted for comparing between deep dose and shallow dose, and one paired t-tests were conducted to compare the averages of deep dose and shallow dose with the reference dose limit once for workers engaged in radiation work and students, apprentices, (over 16 but under 18 years of age who are under training in the radiation field).

Paired sample test SPSS software, version 23 (SPSS Inc., Chicago, Illinois, USA) was used for data entry and analysis. The null hypothesis was the equality l versus the alternative hypothesis of non-equality (2-tailed), and all analyses were carried out at a significance level of 0.05.

RESULTS:

The study sample included 173 students (58 male + 115 Female) with a distribution of 33.5 % male and 66.5% female.

The descriptive analysis of the OSL radiation dose measurements for deep and shallow dose for the whole studied sample of NMT students are illustrated in ***Table (2)***. The mean deep dose OSL measurements were (0.844 ± 0.297), the lowest reading was (0.24 mSv/y), and the maximum was (1.4 mSv/y).

As regards the shallow dose OSL measurements, the mean dose was (0.839 ± 0.297), the lowest reading was (0.24 mSv/y), and the maximum was (1.39 mSv/y). Independent sample T-test shows that there were statistically non-significant differences between deep and shallow dose measurements for the whole studied sample of NMT students ($p > 0.05$).

The mean background measurement for the clinical training sites was (0.3 μSv/hr). These measurements were extracted from the routine measurement records of different working areas for the two main clinical training centers. The average daily number of patients is five patients during the clinical training period.

The ICRP dose limits for workers, students, and public members (illustrated in table 1) stated that the students and apprentices over 16 but fewer than 18 years of age could have a maximum dose limit of 6 mSv/y. For that reason, we have compared the measured doses for students with the maximum dose limit allowed to them as per ICRP recommendation.

The one-sample T-test with a reference number of (6 mSv/y) has been calculated, and the results showed that there was a statistically significant difference ($p < 0.05$) between the average value of OSL measurements for NMT students for both deep and shallow dose measurements with the reference dose limit (6 mSv/y).

Table (1): ICRP dose limit for workers, students, and members of the public.

Dose limit	Workers engaged in radiation work	Students and apprentices over 16 but under 18 years of age	Members of the public
Effective dose (mSv/year)			
five-year average	20/ year	-	1/year
single-year period	50	6	1

Table (2): Descriptive analysis of the OSL radiation dose measurements for deep and shallow doses for the total studied sample of NMT students.

		Deep Dose (mSv/year)	Shallow Dose (mSv/year)
N	**Valid**	173	173
	Missing	0	0
Mean		0.844	0.839
Median		0.9	0.9
Std. Deviation		0.297	0.298
Minimum		0.240	0.240
Maximum		1.40	1.39
Percentiles	**25**	0.595	0.585
	50	0.9	0.9
	75	1.11	1.11

DISCUSSIONS:

Assessing students during their study period in the nuclear medicine technology program is critical as they are preparing for lifelong occupational radiation exposure.

All nuclear medicine technology students in this study received their clinical training in two different centers; one of them is used for training on general nuclear medicine procedures, and the other is for positron emission tomography - computed tomography procedures (PET-CT).

During their internship period, the training centers may vary in their workloads, such as the number of patients per day and the types of radiopharmaceuticals used as well as the training rotation on different areas of the center.

Vanhavere. et al,. have studied the optimization of radiation protection for medical staff and reported that the highest occupational doses for nuclear medicine staff were recorded during the preparation of the ^{18}F doses **(16)**. Most of the procedures and techniques that the students were trained on were performed using gamma emitters for general nuclear medicine procedures and also during PET-CT procedures. They are not involved in the patient injection of PET tracers in their training period.

Alnaaimi et al,. have studied the occupational radiation exposure in a nuclear medicine department, and their results show that the Hp (10) and Hp (0.07) for all nuclear medicine personnel were below the limits set by the ICRP (20 mSv/y) **(2)**. Our study results show that there were non-significant differences between deep Hp (10) and shallow Hp (0.07) OSL measurements. This result is matching with several studies in the literature, which indicates that Hp (10) and Hp (0.07) gives equal measures for gamma radiation **(2, 3, 4, 9 and 10)**.

Tuncay Bayram et al,. in 2011 reported that even without a rotation of the working technologists and a notable increase in the patients' number, the annual dose to technologists did not reach the annual limit (20 mSv) indicated by the International Commission on Radiological Protection **(17)**. Up to our knowledge and literature search, there was no study until the present that monitors the radiation exposure to nuclear medicine technology students; for that reason, the ICRP recommended dose limits were taken as a reference value for comparison.

The results in our study show that the average annual radiation dose received by nuclear Medicine technology students was (0.844 mSv/y) for deep dose measurement and (0.839 mSv/y) for shallow dose measurement.

In comparison with the acceptable dose limit recommended by ICRP, these measurements were very low (1:6) as the students and apprentices who are receiving training in the field of radiation could have a maximum dose limit of 6 mSv/y.

This indicates that there is a safe training environment for students in the nuclear medicine technology program, which is reflected in their monitoring results.

Also, the results of the current study denote that the students were adequately aligned with the regulations exposed to them through the program management, as they strictly follow the radiation protection procedures and measures following their study of their theoretical courses.

CONCLUSIONS:

All nuclear medicine technology students received radiation equivalent doses significantly lower than the ICRP dose limits during their training practice in their study period.

The study denotes a safe training environment for students and proper understanding and application of safety procedures given to the students during their theoretical study courses.

Declarations:

Ethics approval and consent to participate: All students' data collected were under the surveillance procedures performed for all students enrolled in nuclear medicine technology at Inaya Medical College.

The study has got official approval from the Internal Review Board under the supervision of the Scientific Research Unit (SRU).

The study protocol was following the ethical standards of the institutional and national research committees and with the tenets of the 1964 Declaration of Helsinki and its later amendments

Conflict of Interest: The authors declare that they have no conflicts of interest.

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