ORIGINAL ARTICLE

MEASUREMENT OF EXTREMITIES DOSES TO OCCUPATIONAL WORKERS BY USING RING DOSIMETERS

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ABSTRACT

BACKGROUND: Radioactive isotopes are used in nuclear medicine for diagnostic as well as therapeutic purpose. The procedures adopted in nuclear medicine involve handling of unsealed radionuclides and may have direct contact of fingers with unshielded vials and syringes. It is the possibility of extremities contamination while handling unsealed radioactive sources due to which occupational workers gets unwanted radiation exposure. In this regard, a study was conducted in nuclear medicine department of AECH-NORI, Islamabad to evaluate the extremities exposure of radiation workers while performing different diagnostic and treatment procedures. **MATERIAL AND METHODS:** During the study period approximately 90-95% procedures were performed with ^{99m}Tc, 5-6% by using ^{131}I, 1% with ^{201}Tl and 0.25-0.5 % for MIBG. Eight radiation workers (seven nuclear medicine technologists and one radio pharmacist) participated in study and extremity doses were evaluated at Hp(0.07). TLD based ring dosimeters were used to measure the occupational exposure. **RESULTS:** The measured minimum, maximum and average doses were found 9.24 mSv/y, 90.0 mSv/y and 37.2 mSv/y for the technologists of nuclear medicine department. The minimum, maximum and average doses for radio pharmacist were found to be 95.52 mSv/y, 312.96 mSv/y and 204 mSv/y, respectively. **CONCLUSION:** All eight workers were right handed and found that right hand of six workers exposed more than the left hand. The measured results clearly show that the annual extremity doses of radiation workers are within the recommended limits (500 mSv/y).[1]

Keywords: Occupational Exposure, Unsealed radioactive sources, Extremity, Nuclear Medicine, Contamination, Ionizing radiation.

Introduction

Radioisotopes are used in industry, power generation, agriculture, and health sector for the benefit of mankind. Ionizing radiations are used for therapeutic as well as diagnostic purpose to perform various kinds of procedures. The diagnostic procedures involve intravenous administration of radiopharmaceutical while therapeutic radioisotopes are mostly administered through orally. The most commonly radio isotopes used in nuclear medicine department are ^{99m}Tc,^{131}I, ^{201}Tl, ^{32}P and decay with different half lives by emitting beta and gamma rays.[2-5] Performing different procedures in nuclear medicine, radiation workers get whole body as well as extremities exposure. Use of lead glass, lead shields and bricks minimizes the whole body exposure but extremities are in proximity to radiation sources so they get higher exposure than whole body.[6-9]

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The number of medical procedures in nuclear medicine is increasing and needs proper attention to evaluate extremity doses of occupational workers. Extremities dose monitoring of occupational exposures is generally carried out to verify and compliance with the regulatory bodies dose limits. Optimization of doses is necessary to follow the basic safety principles and exposure to occupational workers which are being exposed by ionizing radiation during working hours should be as low as reasonably achievable. Routine monitoring helps to identify the doses to occupational workers and indicate the levels of radiation protection in order to consider the ALARA principle.[8,10] Extremity doses of radiation workers in nuclear medicine department of Nuclear Medicine, Oncology and Radiotherapy Institute (NORI) are monitored for seven months by using ring dosemeters (TLD-100). These dosemeters are convenient to wear during working and can be used in dry, wet and humid environment.

Contamination is also a major factor while handling unsealed radioactive sources due to which occupational workers gets unwanted radiation exposure. From radiation protection point of view it is important to know the extent of radiation exposure to respective hand (left or right) and particular finger of the radiation worker. In this study, eight occupational workers including a radio pharmacist are monitored to assess the ionizing radiation exposure to extremities. Ring dosimeters are not commonly used in nuclear medicine departments of Pakistan to assess extremities doses of occupational workers. The goal of the present study is to determine extremity doses of occupational workers in nuclear medicine department during the preparation and administration of radiopharmaceuticals. The study also includes radiation exposure during image acquisition procedures on gamma camera.

Material and Method

It is an established fact that the radiation workers who are routinely work in controlled and supervised areas are expected to expose more ionizing radiation. Routine personal dosimetry helps to identify individual exposure levels, nature of procedures, and individual workload in the framework of the ALARA principle.[8,11,13] Radiation monitoring of occupational exposures is carried out to compliance with the regulatory dose limits and to demonstrate an appropriate level of radiation protection.

Sixteen ring dosimeters (TLD-100) were given to eight radiation workers to evaluate the extremities doses. The radiation workers who participated in this study include seven nuclear medicine technologists and one radio pharmacist. Each worker was provided two ring dosimeters to wear in index finger of right and left hands. Ring dosimeters were worn in index finger as this finger is exposed more to radiation as compared to others. During working, it was assured that the face of dosimeter remained towards radiation source. The radiation workers were randomly observed to follow the instructions and wearing procedures for TLD usage during working hours.

Each dosimeter has a laser engraved code. In addition to laser engraved code, the name of worker and extra code were marked on the dosimeter to avoid any confusion during use of particular ring dosimeter. To distinguish between right and left ring TLDs, these were color coded with black and white color tapes for right and left hands respectively. The used ring dosimeters (TLD-100) could measure radiation doses in the range of 10 µSv to 10 Sv. The TLD-100 ring dosimeters consist of LiF:Mg,Ti having absorption coefficient 8.2 which is closed to human tissue 7.4.[8,9]

The exposed TLD ring dosimeters were readout after one month in the facility of Pakistan Nuclear Regularity Authority (PNRA) in NDCL with Harshaw Bicron Model 6600E automatic TLD reader. All TLD ring dosimeters were calibrated before use. In order to read exposed TLD, pre heat temperature adjusted at 50°C, temperature rate 15°C and annealing temperature fixed at 300°C.[8] The exposed ring dosimeters were replaced with new ring dosimeters simultaneously at an interval of one month for the purpose of evaluation of doses. Study was conducted for a period of seven months.

Results and Discussion

Occupational radiation doses were measured during preparation and administration of radionuclides in Hot Lab and scanning of the patients on Gamma Camera. In the studied time period, TLD based ring

dosimeters were used to determine the equivalent dose to the extremities of occupational workers who regular work in nuclear medicine department of AECH-NORI, Islamabad. Present study is carried out to assess the extremities doses and compliance with the regulatory body dose limits.

In the studied period, total one hundred and twelve TLD ring dosimeters were used and evaluated. Minimum, maximum and average doses measured were 0.16 mSv, 7.5 mSv and 1.99 mSv per month respectively for the technologists of nuclear medicine department. The minimum, maximum and average doses measured monthly for radio pharmacist was 0.321 mSv, 36.97 mSv and 16.0 mSv respectively. Worker-8 is radio pharmacist, whereas other seven workers are nuclear medicine technologists and all were right handed. The doses of right and left hands of selected workers are shown in (Tab. 1). It is obvious from the table that right hand of six workers was more exposed compared to left hand. The measured average dose of worker-5 is same for both hands and for worker-2; left hand got more dose than right hand in the studied period.

Whole body doses of selected radiation workers, monitored with TLD badges are shown in (Tab. 2). Monthly effective doses are considered to correlate the measured extremities doses. Whole body doses are measured in routine at facility level to incorporate the safety protocols of regulatory body. The exposed badges are read at Radiation Dosimetry Lab, PINSTECH, Islamabad. It is clear from the (Tab. 2) that all measured doses are within the recommended limits. In order to consider the workload, different types of scans and numbers of scans performed in the nuclear medicine department during the study year are shown in (Tab. 3). Apart from these mentioned

Study Period	December		January		February		March		April		May		June	
Worker	Right Hand	Left Hand	Right Hand	Left Hand	Right Hand	Left Hand	Right Hand	Left Hand	Right Hand	Left Hand	Right Hand	Left Hand	Right Hand	Left Hand
1	1.468	1.56	1.76	1.49	1.88	1.76	0.93	1.71	1.46	1.31	0.507	0.41	2.06	1.51
2	0.963	3.55	1.06	2.08	1.89	1.99	1.15	2.17	0.201	0.94	4.65	3.2	1.099	1.41
3	3.34	4.87	1.33	1.19	7.56	6.91	3.31	1.87	3.44	1.56	1.52	2.33	1.063	1.05
4	0.73	0.62	3.50	1.97	3.96	5.92	1.29	0.99	1.47	0.93	0.19	0.17	0.167	0.16
5	4.03	3.14	2.34	1.80	4.81	4.48	0.84	0.78	1.21	1.34	2.18	3.95	1.24	1.11
6	2.87	2.52	1.34	1.29	1.11	0.77	2.51	1.86	0.963	0.77	0.73	0.70	0.721	1.08
7	4.84	1.56	4.08	2.02	3.47	6.4	1.03	1.58	1.31	2.21	2.19	0.86	0.886	0.30
8	36.97	20.2	9.03	7.96	26.08	24.4	10.74	13.2	17.85	22.7	1.80	0.73	0.385	0.32

Table 1: Doses (mSv) for right and left hands of selected workers averaged for each month during study period

Worker	Monthly Doses (µSv)												Total Dose (µSv/y)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	510	130	280	120	130	70	250	110	90	180	170	130	2170
2	610	150	230	70	150	170	230	140	120	160	100	170	2300
3	420	110	160	80	120	90	150	180	150	170	80	250	1960
4	510	90	170	120	70	80	150	190	150	130	160	170	1990
5	390	510	630	190	130	670	450	740	140	450	320	150	4770
6	690	330	220	160	470	380	170	140	290	180	360	100	3490
7	370	160	110	190	90	140	320	170	80	150	200	120	2100
8	660	330	390	440	160	120	380	270	630	390	280	450	4500

Table 2: Whole body monthly doses of radiation workers measured with TLD badges

scans 308 iodine therapy and diagnostic scans are also performed in the same department. The procedures performed in the department are shown to provide the fundamental information regarding the extent of exposure.

Type of scans	Number of scans	Type of scans	Number of scans
Bone	3175	HIDA	141
Cardiac	599	Liver Scan	06
Renal	1999	Lung Scan	31
DMSA	139	Thyroid Scan	3833
G.I.Bleed	22	MIBG	19

Table 3: Scans performed in one year in nuclear medicine department

Comparative equivalent doses of different workers are shown in (Fig. 1). It is obvious from the (Fig. 1) that worker 8 received more dose as compared to other workers. Worker-8 involved in the elution of technetium and kit preparation during studied period and hence got more exposure. It is also clear in the same figure that right hand exposure is more as compared to left hand in 75% cases of present study. Calculated monthly mean doses are shown in (Fig. 2) to make the results more clear. It is obvious from (Fig. 2) that monthly doses of occupational workers are below the recommended limits.

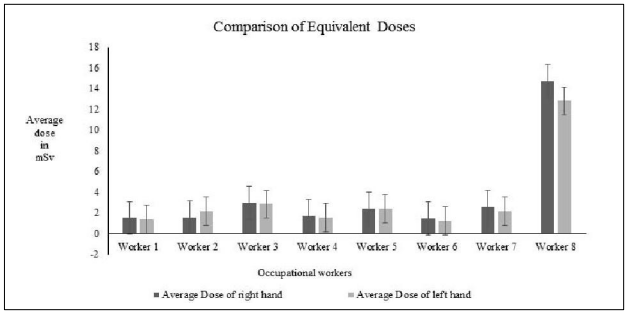

Figure 1: Comparison of equivalent doses of radiation workers

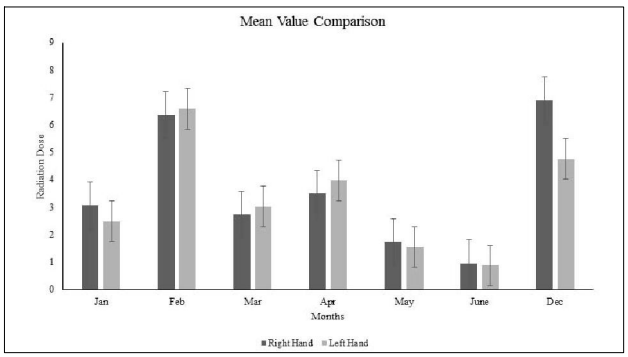

Figure 2: Comparison of mean doses for the study period

The monthly doses were also averaged on yearly basis for comparative purpose. The measured minimum, maximum and average annual doses for technologists are 9.24 mSv, 90.0 mSv and 37.2 mSv. The minimum maximum and average annual doses measured with ring dosimeters for radio pharmacist are 95.52 mSv, 312.96 mSv and 204.0 mSv respectively. These doses follow the trend as monitored by Chruscielewski, Jankowski and Covens shown in (Fig. 3).[14-16] The radiation doses measured in the present study are on the higher side as compared to Chruscielewski.[14] It is observed from the same figure that Jankowski measured minimum annual dose for radio pharmacist is higher than present study and maximum average doses are lower than this study. The present study shows minimum and average annual doses for technologists lower than Covens study[16] while average annual doses for technologists is higher than Covens. However, the measured doses of the radiation workers are well below the recommended limits 500 mSv per year.

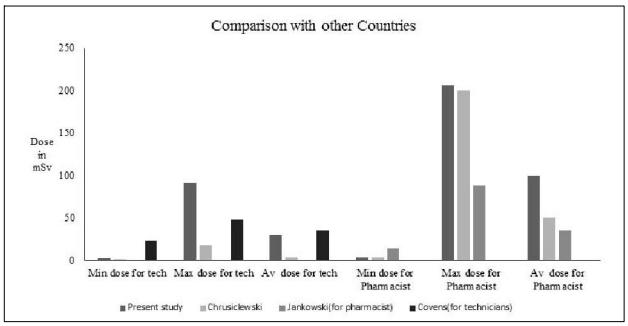

Figure 3: Comparison of present study with other countries

Conclusions

Ionizing radiation is extensively used in medical practices and the largest group of workers occupationally exposed to man-made sources of radiation. Extremities are more prone to radiation exposure during preparation and administration of doses in Hot Lab and may have direct contact of the fingers with unshielded vials and syringes. TLD based ring dosimeters are used and measured minimum, maximum and average doses per month found 0.16 mSv, 7.56 mSv and 1.99 mSv respectively for the technologists. The minimum, maximum and average doses measured per month for radio pharmacist are 0.321 mSv, 36.97 mSv and 16 mSv, respectively. All selected

workers were right handed and calculated results indicate that right hands of 75% workers were more exposed as compared to left hands. The measured doses of radiation workers were within the acceptable limits. Extremities doses of occupational workers can be substantially reduced to optimize the procedure protocols and follow the proper safety culture. It is recommended that extremities doses should be routinely monitored and use of radiation protective devices and shields might reduce occupational doses significantly.

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References

1. International Commission on Radiological Protection. ICRP Publication 103: Recommendations of the ICRP. Annals of the ICRP 2008.

2. Kemerink GJ, Vanhavere F, Barth H, and Mottaghy F. Extremity doses of nuclear medicine personnel: a concern. Eur. J. Nucl. Med. Mol. Imag. 2012; **39:** 529-32.

3. Dhanse S, Martin CJ, Hilditch TE and Elliott AT. A study of doses to the hands during dispensing of radiopharmaceuticals. Nucl. Med. Comm. 2000; **21:** 511-29.

4. Berus D, Convens P, Broeck MVD, Holsbeeck GV, and Vanhavere F. Extremity doses of workers in nuclear medicine: Mapping hand doses in function of manipulation. IRPA 11 Proce. Spain. 2004; 23-8.

5. Martin CJ. Strategies for assessment of doses to the tips of fingers in nuclear medicine. J. Radiol. Prot. 2016; **36:** 405-18.

6. IAEA. Practical radiation technical manual, personal protective equipment. IAEA-PRTM-5. IAEA: Vienna, 2004.

7. F. Vanerence, D. Berus, N.Buls and P.Covens. The use of extremity dosemeters in a hospital environment. Radiat. Prot. Dosim. 2006; **118(2):** 190-5.

8. Antonia S. thesis, Personnel TLD monitors, their calibration and response. 2010.

9. Sandouqa AS, Haddadin IM, and Abu-Khaled YS. Hand equivalent doses of nuclear medicine staff in Jordan: Preliminary experimental studies. Radiat Meas. 2011; **46:** 250-3.

10. Bilska HP, Birkenfeld B, Listewnik B, and Zorga P. Long-term monitoring of radiation exposure of employees in the department of nuclear medicine (Szczecin, Poland) in the years 1991-2007. Radiat. Prot. Dosim. 2010; **140(3):** 304-7.

11. Vanhavere F, Carinou E, Donadille L, and Ginjaume M et al. An overview on extremity dosimetry in medical applications. Radiat. Prot. Dosim. 2008; **129(1-3):** 350-5.

12. Shousha HA, Farag H, and Hassan RA. Measurement of doses to the extremities of nuclear medicine staff. Rad. Eff. and Def. in Solids. 2010; **165(1):** 16-22.

13. Wrzesien M, Olszewski J, and Jankowski J. Hand exposure to ionizing radiation of nuclear medicine workers. Radiat. Prot. Dosim. 2008; **130(3):** 325-30.

14. Chrusicielewski W, Olszewski J, Jankowski J, and Cygan M. Hand exposure in nuclear medicine workers. Radiat. Prot. Dosim. 2002; **101(1-4):** 229-32.

15. Jankowski J. Olszewski J, and Wrzesien M. The equivalent dose for different part of hand for nuclear medicine workers. World Cong. Med. Phy. Biomed. Eng. 2006; **4(12):** 2099-101.

16. Covens P, Berus D, Clerinx P, and Vanhavere F. Personal dose monitoring in hospitals: global assessment, critical applications and future needs. Radiat. Prot. Dosim. 2007; **124(3):** 250-9.