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RESEARCH ARTICLE

A Study on Personnel Dosimeters

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Summary

Dosimeters are used to measure and control the dose of radioactivity exposure by personnel working with radioactivity. There are two types: film-badge (FBD) and thermoluminescent (TLD) dosimeters.

These dosimeters are periodically measured and evaluated by the Turkish Atomic Energy Authority (TAEK)-Dosimetry Service. These evaluations take place monthly for FBDs and bimonthly for TLDs.

We present in this study the results of our investigation of the radioactivity dose exposure of personnel who work with radioactivity at the radiopharmacy laboratory using both types of dosimeters. The conformity of the level of radioactivity dose to international standards is also discussed.

Key Words : *Personnel dosimeter, thermoluminescent dosimeter, film-badge dosimeter.*

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Personel Dozimetreleri Üzerine Bir Çalışma

Özet

Radyoaktivite ile çalışan personelin maruz kaldığı radyoaktivite dozu, bu personel tarafından kullanılması zorunlu olan dozimetreler ile ölçülür ve takip edilir. Bu amaçla sıklıkla kullanılan dozimetreler iki tiptir. Bunlar film-badge dozimetreler ve termolüminesans (TLD) dozimetrelerdir.

Bu dozimetreler çeşitli periyotlarda Türkiye Atom Enerjisi Kurumu-Dozimetre Servisi tarafından ölçülerek değerlendirilir. Bu değerlendirmeler film-badge tipi dozimetreler için aylık, TLD tipi dozimetreler için iki aylık periyotlar halinde yapılmaktadır.

Bu çalışmada radyofarmasi laboratuvarında radyoaktivite ile çalışan personelin bu değerlendirmeler sonucu aldığı radyoaktivite dozları her iki tip dozimetre kullanılarak karşılaştırmalı olarak verilmiştir. Personelin aldığı radyoaktivite dozlarının uluslararası standartlara uygunluğu araştırılmıştır.

Anahtar Kelimeler : *Personel dozimetresi, termoluminesan dozimetre, film dozimetre.*

INTRODUCTION

A very important part of following ALARA (As Low As Reasonably Achievable) principles and determining whether personnel are being excessively exposed to radioactivity, either due to poor handling techniques on the part of the worker or the use of a system that allows for greater contamination to exist, is the establishment of a formal program for personnel monitoring and bio-assay[1].

Such monitoring is necessary to ensure personnel exposure to radiation is maintained within relevant dose limits. It also permits monitoring of new techniques to ensure that their introduction does not cause an unacceptable level of radiation exposure[2].

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Personnel monitoring is required under the following conditions[3]:

a - For individuals entering high or very high radiation areas,

b - For occupational workers, including minors and pregnant women, likely to receive in 1 year a dose in excess of 10% of the annual limit of exposure from the external radiation source.

Personnel dosimeters are used to monitor personnel exposure to radiation in the radiopharmacy laboratory.

A variety of dosimeters can be used to determine personnel radiation exposure:

i- Pocket dosimeters

ii- Film-badge dosimeters (FBD)

iii- Thermoluminescent dosimeters (TLD)[1-3].

The second most common device utilized for personnel monitoring is the FBD, which consists of a piece of X-ray film inside a paper envelope. The badge is contained within a plastic holder which has five windows of different size and shape so that the type of radiation falling on the X-ray film can be evaluated[2].

A plastic film badge holder is shown in Figure 1.

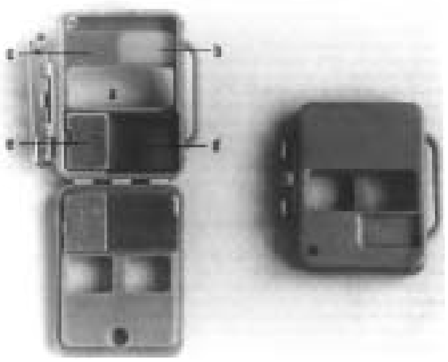

Figure 1. Plastic Film Badge Holder (1). a: open window, b: 0.5 mm plastic window, c: 3.0 mm plastic window, d: plastic light /alloy window, e: plastic tin, lead window[2].

The second most common personnel dosimeter used for monitoring is the TLD. The most frequently used TLD contains activated LiF crystals. A few milligrams of LiF are placed in a small sachet so that it can be conveniently worn on the hand. It is also available in the form of a pocket dosimeter, also containing LiF3 crystals. If the radiation exposed crystals are heated to 300-400°C, it emits fluorescent in proportion to the amount of radiation absorbed in the TLD. A thermoluminescent dosimeter is shown in Figure 2[2].

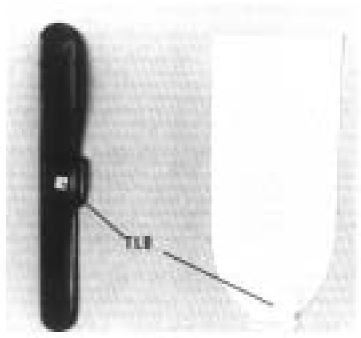

Figure 2. Thermoluminescent Dosimeter TLD[2]. Left: TLD incorporated into plastic strip; Right: TLD attached at the end of a finger stall.

The aim of this study was to monitor the dose of exposure to radioactivity by personnel while preparing, dispensing and conducting quality control of radiopharmaceuticals in a radiopharmacy laboratory. In addition, environmental exposure to radioactivity in the radiopharmacy/medical field will be determined.

MATERIALS and METHODS

Two personnel dosimeters [FBD (PTW-Freiburg/Germany) and TLD (Panasonic/Japan)] were used to monitor the dose of radiation exposure in this research. The FBD was evaluated on a monthly basis and the TLD on a bimonthly basis by the Turkish Atomic Energy Authority (TAEK)- Dosimetry Service.

The calibration of TLD dosimeters is done using standard Cesium source and validated for Technetium. **Hp (0.07) personnel equivalent unit of dosimeter service is used as measurement unit.** TAEK-Dosimeter Service conducts this review periodically.

For environmental dose exposure, change of background activity throughout the day in the radiopharmacy laboratory on the counter and in the laboratory was monitored by Radiation Alarm Monitor (S.E. International).

RESULTS and DISCUSSION

Personnel monitoring results using the various dosimeters (FBD, TLD, TLD-finger) are shown in Tables 1-3.

Table 1. Film-Badge values of four consecutive months

Period (2003)	Measured Dose (mSv.month^{-1}) Operator	Measured Dose (mSv.month^{-1}) Other Operator	mSv.year^{-1} ICRP
May	0.20	0.50	50
June	0.25	< 0.10	
July	1.50	< 0.10	
August	< 0.10	0.25	

Table 2. Thermoluminescent values for the whole body

Period (2003)	Measured Dose (mSv.month^{-1}) Operator	Measured Dose (mSv.month^{-1}) Other Operator	mSv.year^{-1} ICRP
Sept.- Oct.	5.18	1.11	50
Nov.- Dec.	1.14	0.63	

Table 3. Thermoluminescent values for the finger

Period (2003)	Measured Dose (mSv.) Operator	mSv.cm^{-2}.year^{-1} ICRP
August	37.03	500

All three dosimeters (FBD, TLD, and TLD-finger) showed that the doses of exposure of personnel to radiation were within the limits of the ICRP (International Committee for Radiation Protection), i.e. 50 mSv.year^{-1}, for radiation workers. **Working of the operator alone increased the exposed dose significantly.**

The main disadvantage of the FBD is the long waiting period before the worker is aware of his exposure level. The FBD also tends to fog due to heat and humidity, particularly when in storage for an extended period, and this may obscure the actual exposure reading[3].

Additional work (e.g. research) aside from the daily routine in the laboratory also dramatically increased the dose of exposure of the operator.

It was also observed that the fingers receive higher doses of radiation than other parts of the body. Measurements have demonstrated that the radiation dose absorbed by the thumb during preparation of radiopharmaceuticals can be approximately twice that received by the index finger[4]. This is due to the fact that the thumb was used to depress the plunger of the syringe when adding radioactive solutions to vials in these manipulations. This indicates the importance of careful selection of the areas to be monitored with TLDs.

The results of enviromental exposure monitoring are illustrated in Table 4. **Off days of operator decreased the exposed dose**. Enviromental radiation doses measured on the counter and in the laboratory were within acceptable limits at the beginning of the day, increased throughout working hours and returned to normal level at the end of the work day.

Table 4. Changes in background radioactivity throughout the day

On the Counter	Doses (mR. h^{-1})						Avg.
08^{00}	0.24	0.20	0.18	0.20	0.22	0.18	0.20
12^{00}	1.20	1.90	0.80	1.20	2.10	1.40	1.43
16^{00}	0.44	0.20	0.20	0.46	0.60	0.46	0.39
In the Laboratory	Doses (mR. h^{-1})						Avg.
08^{00}	0.18	0.20	0.20	0.22	0.22	0.18	0.20
12^{00}	3.00	1.00	0.35	0.70	2.00	1.10	1.36
16^{00}	0.26	0.16	0.18	0.30	0.65	0.40	0.32

It is important that contaminated surfaces or equipment be identified as soon as possible so that the necessary remedial action can be taken. The majority of work in radiopharmacy laboratories involves Tc-99m. In view of its six-hour shelf-life, it may be convenient to cover surfaces which are difficult to clean with suitable shielding for a period of 24 hrs to allow activity to decay prior to applying further decontamination procedures. Similarly, it may be convenient to remove contaminated equipment, e.g. shielding vials/tongs to a suitable storage area prior to performing decontamination procedures[2].

Where contamination persists, it may be necessary to resort to stronger cleaning agents. Decontamination solutions containing surface-active or chelating agents are commercially available. If small pieces of equipment become contaminated with long-life radionuclides, or short-life radioactivity is difficult to remove, it may be economically preferable to discard them as radioactive waste rather than apply extensive decontamination procedures[2].

CONCLUSION

This study investigated radioactivity in the radiopharmaceutical/medical field. Personnel and environmental monitoring are important to ensure protection from radiation for individuals working in this capacity.

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