Iran. J. Radiat. Res., 2004; 2 (2): 75-78

Assessment of radiation dose in nuclear medicine hot lab

M.M. Ahasan*

Centre for Nuclear Medicine & Ultrasound, Rajshahi, Bangladesh

ABSTRACT

Background: Hot lab is a specially designed room in a nuclear medicine hospital where the radiopharmaceuticals are delivered, stored and prepared for dispensing. ^{99}Mo/^{99m}Tc-generator is the major source in the hot lab used for various medical imaging. It is important to maintain a standard for hot lab procedures to optimize the patient care and minimize radiation exposure to all nuclear medicine personnel, patients, public, as well as environment.

Materials and Methods: The radiation doses in the hot lab were measured by GM and NaI Detectors for about 12 months. Package surface doses and generator surface doses were also measured. An increase in the counted rate above background was considered for the study. A constant distance was made in every step.

Results: At the receipt date, the ^{99}Mo/^{99m}Tc-generator surface dose (450±150 μGy/hr) found to be nearly six times higher than the package surface dose (80±20 μGy/hr). The dose rate at the outer surface of the fume-hood glass found to be 80±15 μGy/hr in the 1st day of generator placement, whereas at the 2nd day it was 70±12 μGy/hr; showing a gradual decline in dose rate during 3rd (50±10 μGy/hr), 4th (40±9 μGy/hr), 5th day (30±6 μGy/hr) and 6th day (25±4 μGy/hr).

Conclusion: In the 1st day of a generator storing in the hot lab, the dose rate found to be 3-4 times higher than the 6th days. The dose rate at various places indicated poor performance of the fume-hood glass. The study emphasizes on the need of growing awareness among all the radiation workers and encouraging the safe working practices in nuclear medicine. *Iran. J. Radiat. Res., 2004; 2 (2): 75-78*

Keywords: *^{99}Mo/^{99m}Tc-generators, radiation survey meters, hot lab, radiation workers.*

INTRODUCTION

All the nuclear medicine facilities in the World use some common radionuclide such as ^{99m}Tc, ^{131}I, ^{125}I, ^{129}I, ^{137}Cs, ^{90}Sr, ^{32}P, ^{57}Co for calibration, diagnostic use and therapeutic modalities, as well as academic and research activities. Radiation can interfere with the body and potentially cause harm. It has several benefits and risks at the same time. It is recommended by regulatory agencies that no minimum radiation is safe. It can potentially cause both somatic and genetic effects including development of cancers and congenital anomalies. The effects and dangers of some forms of radiation are not completely known. It is very difficult to detect all reasons. Some health effects of ionizing radiation are well known, yet some other are controversial. Workers in nuclear medicine can be exposed to many different forms of radiation. Health and safety representatives need to know about what the effects are, and what can be done in nuclear medicine workplaces to reduce the risks.

For radiation safety issue, nuclear medicine facilities are divided into two parts: i) controlled area, and ii) supervised area. Hot lab is named as controlled area/room where radionuclides are always stored. The workers have to work in the hot lab. The workers spend most of their time for patient dose preparation. Therefore, keeping exposure below the radiation protection issue in

* **Corresponding author:**
M. Monjur Ahasan, Centre for Nuclear Medicine & Ultrasound, Rajshahi Medical College Hospital Campus, P.O.Box: 35, Rajshahi 6000, Bangladesh.
Fax: +880 721 775892
E-mail: cnmuraj@bttb.net.bd

the hot lab is an important factor. ^{99m}Tc is used in nuclear medicine frequently, which is generally stored in the hot lab fume hood. The ^{99}Mo/^{99m}Tc-generator currently provides labeling material for the large majority radionuclide imaging studies performed worldwide (Richards *et al.* 1982). A number of regulations dealing with the receipt, handling and disposal of generators have been developed (NRC 1987). As there is currently insufficient data about radiation level in the nuclear medicine hot lab and policy available to decide whether the workers should be kept safely, and radioactive wastes should be disposed of or be subjected to long-term storage. The current philosophy of radiation protection is based on the assumption that any radiation dose, no matter how small, may result in human health effects, such as cancer and hereditary genetic damage. But doses of ionization radiation less than 0.1Gy are critical for risk assessment of the general public, as well as of radiation workers (UNSCEAR 2000). Therefore, it is important to do research in the spectrum of the present work.

MATERIALS AND METHODS

The inner surface of the hot lab was logically divided into some parts for convenient measurements of radiation dose. The measurement was performed for 12 months and 10 generators from Nycomed Amersham plc were randomly selected for the study. Exposure rates at 0.15m, 0.3m and 0.6m distances from the fume-hood were measured by a high sensitive portable Dose Ratemeter [Model: DRGE-31, Serial No: 110301], and a NAI detector. Inner and outer door surfaces were also measured at the same time. The Dose Ratemeter was calibrated by Standard Secondary Dosimetry Laboratory, Institute of Nuclear Science and Technology, AERE, BAEC, Dhaka. Package surface dose, generator surface dose and dose rate at 1m distances from the surface were also measured for every case. The background radiation was measured outside the hot lab and subtracted in all measurements independently.

RESULTS

The generator surface dose rate containing nearly 270 mCi of Mo was measured in the first day (450±150 μGy/hr). Package surface dose rate in the same day was measured 80±20 μGy/hr and dose rate at 1m distance from the package found to be 8±3 μGy/hr. The outer surface dose rate of the fume-hood glass was 80±15 μGy/hr in the 1st day of generator placement, whereas in the 2nd day, it was 70±12 μGy/hr. The same procedure continued during the 3rd (50±10 μGy/hr), 4th (40±9 μGy/hr), 5th (30±6 μGy/hr) and the 6th days (25±4 μGy/hr). Detailed results are shown in table 1.

Table 1. Showing the mean radiation level in and around the Hot lab of CNMU at Rajshahi during the last one-year (when a new ^{99}Mo/^{99m}Tc-generator was placed in the fume-hood, the radiation level was measured for the next six days).

Generator placement time	Exposure rate at different distances from the fume-hood in μGy/hr [Mean value ± S.D.]				Inner door surface of the Hot lab in μGy/hr [Mean value ± S.D.]	Outer door surface of the Hot lab in μGy/hr [Mean value ± S.D.]
	Outer surface	0.15m	0.30m	0.60m		
1st day	80±15	40±10	25±8	10±4	1.0±0.7	0.4±0.3
2nd day	70±12	35±9	23±8	9±3	1.0±0.6	0.3±0.2
3rd day	50±10	25±8	18±6	7±3	0.7±0.4	0.2±0.1
4th day	40±9	20±6	15±4	6±3	0.5±0.3	0.2±0.1
5th day	30±6	15±4	10±4	5±2	0.4±0.2	0.2±0.1
6th day	25±4	13±4	8±3	4±2	0.4±0.2	0.2±0.1

DISCUSSION

Radiation cannot be detected by human senses. A variety of instruments is available for detecting and measuring the radiation. Monitoring the results of radiation dose are easy to be done, but the assessment procedure is very complicated and often the implied doses are quite small. If the monitoring results are not significant, a measurement should be done to make records even in these cases. Areas like hot lab for dispensing and storage are classified as controlled areas, where patients, non-radiation workers and public are not allowed in. The dose rate in controlled areas should not be more than 10 μGy/hr. If it is more there need to be more shielding and special safety measures. The ^{99}Mo/^{99m}Tc-generators are often delivered from the company with enough lead shielding for transport purposes, but there may also need to be placed behind an additional lead shield when set up for use in the workplace. The dose rate at the ^{99}Mo/^{99m}Tc-generator surface at the receipt date was 450±150 μGy/hr. Package surface dose rate in same day was 80±20 μGy/hr, and dose rate at 1m distance from the package was 8±3 μGy/hr. So, the generator surface dose found to be six times higher than the package surface dose. The dose rate at the outer surface of the fume-hood glass was 80±15 μGy/hr in the 1st day of generator placement whereas in the 6th day, it was 25±4 μGy/hr. If the dose rate at the generator surface is more than 10 μGy/hr, additional lead shielding is required. The suitable thicknesses of lead shielding are 3-5 mm for ^{99m}Tc, 0.5-2.5 cm for ^{131}I and at least 5 cm for ^{99}Mo. The half-value layer (HVL) of lead for the nuclear medicine radioisotopes are ranged between 0.003-0.70 cm (Islam *et al.* 2001). For workers and hot lab environment safety from continuous radiation exposure, high-density bricks and concrete may be used as good shielding materials.

In the United States, the average occupational dose of workers due to medical use of radioactive materials is 0.22 rem (2.2 mGy), and 94% of medical workers have an annual dose of less than 0.5 rem (5 mGy) (NUREG-0714 1979). In the present study, the average occupational doses for nuclear medicine workers were found to be 1.9±0.5 mGy and most of the workers had an annual dose of less than 4 mGy (NUREG-0714 1979). A licensee must conduct its activities such that the external dose rate in an unrestricted area is less than 0.002 rem (0.02 mGy) in one hour time (20 μGy/hr) (Henkin 1996). In the study, we found such dose rate less than 1 μGy/ hr. A gamma dose rate of 0.5 μGy/hr for a working year (2000 hr) would lead to an annual effective dose of about 1 mGy, and this dose rate or some multiple of it might be adopted as an action level (IAEA 1996). In most practices, doses received by workers are well below the appropriate limits in the BSS. The Standard sets the effective occupational dose limit at 20mGy per year, averaged over a period of 5 consecutive years. The public dose limit is set at 1mGy in a year. However, in nuclear medicine practices we have to take necessary action according to ALARA principle keeping exposure low.

An increase in the count rate or exposure rate above background indicates the presence of radiation. Background radiation at different levels was not considered in this study due its variation as to time. It can be measured easily by a suitable survey meter, but difficult to differentiate if the extra radiation source is present at the study area. The average radiation level was 0.5±0.3 μGy/hr in the workplace of nuclear medicine laboratory. This level was slightly higher than the level of background radiation. Radiation level assessments are generally considered if monitoring indicates that the corresponding annual effective dose exceeds 1 mGy. For visitors, making short and infrequent visits to hot labs, such that there is no likelihood of any significant exposure, so individual monitoring and record keeping is not important. Every facility need to establish a procedure that indicates how monitoring data and results are to be reported, what dose levels are to be recorded and what documents and records of radiation exposure should be maintained. Radiation exposures must be kept less than 2 mR/hr (20 μGy/hr) at one foot

(0.3048m) from a radiation source and less than 0.4 mR/hr (4 μGy/hr) (ALARA) anywhere else in the room.

Operating philosophy for maintaining occupational exposures as low as possible is reasonably achievable. One can reduce his exposure to a radioactive source by a) using shielding, b) reducing the time of exposure, and c) increasing the distance from the source. Although there is a potential possibility for radiation exposure in this field, it is kept to a minimum by the use of shielded syringes, gloves, and other protective devices and adherence to strict radiation safety guidelines. Technologists also wear badges that measure radiation levels. Because of safety programs, however, badge measurements rarely exceed established safety levels. As Low as Reasonably Achievable (ALARA) is a program to restrict actual occupational exposures to less than 10% of Maximum Permissible Dose (MPD). Risks associated with radiation exposure cannot be eliminated, but can be restricted by practicing safety culture in the hot lab as well as all laboratories in nuclear medicine.

This study may lead to an increased awareness for reduction of occupational exposure, especially for those involved in preparing patient dose in the nuclear medicine hot lab. In addition, the study emphasizes the need to grow awareness among all the radiation workers and is to provide guidance to control occupational exposures for encouraging safe working practices in the hot labs, as well as all laboratories in nuclear medicine.

CONCLUSION

Aiming to get maximum benefit amid minimum risk of radiation hazards in nuclear medicine activities, each nuclear medicine facility should be taken ALARA principle properly. A good quality fume hood glass must be setup. Special care should be taken properly in the hot lab, especially at the receipt date of a new generator with the view to keep radiation exposure low.

ACKNOWLEDGEMENT

I am grateful to Dr. Farid Uddin Ahmed, Director of CNMU, Rajshahi for his kind permission to do such research and special thank to Mr. Robiul Islam, Scientific Assistant, for his technical assistance.

REFERENCES

Henkin R.E. (1996). Nuclear Medicine, Vol-I, Mosby-Year Book Inc., *Missouri, pp: 30-39.*

IAEA (1999). Occupational Radiation Protection. IAEA Safety Standards Series No. *RS-G-1.1.*

Islam N., Reza S., Alom Z., Afroz K. *et al.* (2001). Design of special lead shielding facilities for medium and low energy gamma radiation. *Bangladesh J. Nucl. Med.,* ***4:****5-9.*

NRC (1987). Guide for the preparation of applications for medical use programs, NRC Regulatory Guide 10.8, Washington, DC, Nuclear Regulatory Commission.

NUREG-0714 (1997). Occupational radiation exposure, US Nuclear Regulatory Commission, Washington, DC, US Government Printing Office. *pp: 12-13.*

Richards P., Tucker W.D., Srivastava S.C. (1998). Technetium-99m: an historical perspective. *Int. J. Appl. Radiat. Isot.,* ***33:*** *793-799.*

UNSCEAR (2000). Sources and effects of ionizing radiation, United Nations Scientific Committee on the Effects of Atomic Radiation, Report to General Assembly, United Nations, New York.