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RADIATION MONITORING IN A NEWLY ESTABLISHED NUCLEAR MEDICINE FACILITY

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Abstract

A study of area monitoring in a nuclear medicine department's new physical facility was performed for 3 months to ascertain the level of radiation protection of the staff working in nuclear medicine and that of the patients and patient's attendants. Exposure to nuclear medicine personnel is considered as occupational exposure, while exposure to patients is considered medical exposure and exposure to patients' attendants is considered public exposure. The areas for the sources of radiation considered were the hot laboratory, where unsealed isotopes, radionuclides, generators are stored and dosages are prepared, the patients' waiting room, where the radioactive nuclides are administered orally and intravenously for diagnosis and treatment and the SPECT rooms, where the patients' acquisition are taken. The monitoring process was performed using the TLD supplied and measured by the Health Physics Division of Bangladesh Atomic Energy Commission.

The result shows no over-exposure of radiation from any of the working areas. The environment of the department is safe for work and free from unnecessary radiation exposure risk.

1. Introduction

The biological dosage of radioisotopes used in nuclear medicine for diagnostic purposes is generally in the magnitude of 30mCi and the dose administered for therapeutic purposes can be as high as 250mCi. Given the dosage range it is important that no one is subject to unnecessary radiation exposure. In fact there should be adequate precautions starting from the design of the facility to the processes/protocols of administration of isotope dosage and waste management in place in a nuclear medicine facility/department to ensure that the personnel, patients and their attendants (general public) are minimally exposed to radiation. Concern for the personnel is of great importance as they operate in this work environment all year round and if there is a safety shortfall at any physical location or stage of operation, they will be at risk of unhealthy exposure.

The Nuclear Safety and Radiation Control Act [1] and Nuclear Safety and Radiation Control Rules [2] in Bangladesh impose legal requirements to keep doses within acceptable limits in accordance with international standards [3]. An effective dose limit for an occupational worker is 20 mSv/year and for public it is 1 mSv/year.

Routine radiation monitoring programs using thermoluminescence dosimetry (TLD) [4] are in place in all nuclear medicine departments to ensure that the dose limit is not exceeded. However, when a new nuclear medicine facility is established, it is imperative that initially extensive monitoring is done to ensure that the entire facility, especially where the potential for hazards are high, are free from unnecessary radiation risks.

Our nuclear medicine department recently moved to a new physical facility in the same hospital premises at Dhaka, Bangladesh. The aim of this study is to monitor the working area, especially those areas where the risk of radiation exposure is considered high, such as the hot-laboratory (hot-lab), where isotopes are eluted from the generator and dispensed for the preparation of radionuclides in injection or oral forms, the patients' waiting room where these doses are administered and the area surrounding the gamma camera where the patients are examined. The monitoring process is performed using TLD which are supplied and measured by the Health Physics Division of Bangladesh Atomic Energy Commission.

2. Materials and Methods

All the rooms in the new facility are made of concrete with 35cm thick walls. The monitoring process is performed using fifteen TLD that were supplied by the Health Physics Division of Bangladesh Atomic Energy Centre, Bangladesh. We placed fifteen TLD for 3 months in different locations within the hot-lab, areas adjacent to the hot-lab, the patient waiting room and in the SPECT gamma camera rooms.

Five TLD were placed (Table 1) in the hot-lab one above each of the three dose calibrators at the nearest wall. The TLD placed in the back wall of the dose calibrator-1 was placed in a position 40 cm above the calibrator. Similarly the TLD's for dose calibrators-2 and 3 were placed in the same manner at 40 cm and 35 cm, respectively.

One TLD was placed about 50cm above the isotope generator (this is a separate space within the hot-lab) and another TLD was placed above the iodine (131) container at a distance of about 45 cm.

We placed 3 TLD in SPECT room-1 which houses a dual head SPECT system gamma camera, this room is 9 meters away from the hot-lab. The first one was placed near the wall which is close (a distance of 150cm) to the acquisition bed of the SPECT gamma camera gantry. The second TLD in the same room was placed near the wall close (a distance of 180cm) to the acquisition desk where the technologists monitor the patient study during acquisition. The distance between the SPECT bed and the acquisition table is about 2m. The third TLD was placed near the wall at a distance of 200cm from the processing desk where usually the technologists process the image and the physicians give reports.

SPECT room-2 is 15 meters away from the hot-lab and we placed one TLD at the wall close to the SPECT gamma camera at a distance of 120cm. This is a single head SPECT system gamma camera. Another TLD was placed in a single head SPECT room-3 which is 21 meters away from the hot-lab and the TLD was placed 170cm from the gamma camera.

SPECT room-4 is 26 meters away from the hot-lab. Three TLD were placed in this dual head SPECT room in three different places just as in SPECT room-1. Here the distance between the gamma camera and the acquisition desk is 2 meters. The distance between the wall, where the TLD is placed, and the acquisition bed is 180cm. The distance between the acquisition desk and the wall, where the TLD is placed, is 200cm and the distance between the wall, where the TLD placed, and the processing desk is 180 cm.

3. Results

In SPECT room-1 about 620 patients were examined within the study period (3 months). In the same period, about 580 patients were examined in SPECT room-2, 575 patients were examined in SPECT room-3 and about 610 patients were examined in SPECT room -4.

The monitoring results during the study period of the new nuclear medicine physical facility are shown in Table 1.

Table 1: Radiation monitoring data in hot-lab and in the vicinity of hot-lab.

Location	**Position of TLD's**	**Ave dose (mSv) [Mean**
Hot-lab	Above dose calibrator-1	4.47±0.186
	Above dose calibrator-2	12.62±0.799
	Above dose calibrator-3	2.13±0.101
	Above Isotope generator	36.58±4.945
	Above I-131 Container	7.78±0.989
SPECT Room -1	At the wall close to acquisition bed of SPECT	0.87±0.053
	At the acquisition desk of SPECT	0.61±0.079
	At the processing desk of SPECT	0.92±0.377
SPECT Room-2	At the wall close to SPECT	0.78±0.026
SPECT Room-3	At the wall close to SPECT	0.78±0.136
SPECT Room-4	At the wall close to acquisition bed of SPECT	0.83±0.013
	At the acquisition desk of SPECT	0.66±0.023
	At the processing desk of SPECT	0.77±0.069
Corridor	In front of Hot-lab	0.86±0.038
Patient's waiting Room	In the ceiling - placed centrally	1.50±0.378

We can see from the table that the reading near the dose calibrator-2 is higher than the other two calibrators. The equivalent annual dose at this calibrator was about 50.48 mSv/year. In the vicinity of the Tc-99m generator the reading is about 146 mSv per year. For the SPECT rooms, the average dose is almost similar, around 3.22 mSv /year. In the patients' waiting room where radionuclides are either injected or given orally, the measured dose is 6 mSv per year.

4. Discussion

Care must be taken during the establishment of a nuclear medicine department in terms of radiation protection and should follow the local and international regulatory guide for radiation protection. In practice, the exposures of individuals to radiation should be kept as low as reasonably achievable.

It is recommended that radiation exposure to the general public should be limited to an effective dose of 1 mSv/year and for the occupational workers this limit is 20 mSv per year, averaged over defined periods of 5 years [3].

In the vicinity of the Tc-99m generator the reading is high which is predictable as this area is considered as a controlled area.

Near the dose calibrator number 2, the dose is also higher compared to the other two calibrators. The dose of about 50.48 mSv/year is higher than the recommended dose limit. The reason why the reading in calibrator 2 is high is because this calibrator was being used more frequently than the other calibrators. There should be a method to ensure that usage distribution is even among all the calibrators, this will result in a specific area not to be over exposed. Periodic rotation (every 3 months) of technologists working in the hot-lab is also essential. This is to reduce the risk of over-exposure which may result if a technologist is working in the hot-lab continuously during the year. Technologists should have work distributed in other areas of the Department so that their exposure is minimized and balanced. No one was found to be over-exposed during their regular TLD measurement.

For the SPECT rooms the dose is almost the same for all rooms, this is because a balanced number of patients were serviced to each of the camera rooms. Although the acquisition desk is closer to the SPECT gantry than the processing desk, it is seen that the average dose is higher at the processing desk. This is because there are lead shield screens in SPECT rooms -1 and 4 between the SPECT gantry and the acquisition desk. These areas are also considered as controlled or supervised areas.

Again in the patients waiting room the average dose, though still within acceptable limit, is slightly higher than average because about 10 patients sit together after receiving either Tc-99m or Iodine or other radionuclides. Therefore, it is understood that there will be a higher dose compared to other places and this is why it is also designated as a supervised area.

The adjacent upper and lower levels of the hot-lab were checked daily in working days with a survey meter (GM Counter) for 1 month and the dose rates were found to be at the background level.

Radiation awareness among technicians and other occupational personnel is very important to combat unnecessary exposure. There is a need to re-iterate these issues even when the hazard is known to them. As we cannot see and feel the gamma rays it is not easy to be conscious of their presence at all times. It would be a good idea to mark areas of higher activity such as in the vicinity of the Tc-99m generator with labels showing the potential exposure hazard in explicit numbers so that occupation personnel are constantly reminded of the danger of over-exposure.

The three basic radiation safety principles: time, distance and shielding need to be followed at all times to protect against being over-exposed to radiation. Further study needs to be done for the calculation of the average dose for 12 months for more precise results.

5. Conclusion

It is important that the physical infrastructure is designed with radiation safety in mind. Processes and protocols should also be developed, documented and followed to minimize exposure. Radiation awareness is another area which can help reduce unnecessary radiation risk. Sometimes the personnel may neglect the potential hazards of excessive radiation exposure due to lack of awareness or lack of knowledge. Awareness may be improved by periodic information dissemination as well as using techniques to remind the presence of exposure risk.

Irrespective of all the precautions that may be implemented, there is still a need to test whether the design, process, protocol and awareness are at the desired level and therefore it is essential to perform area monitoring in a newly established nuclear medicine department.

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