# Assessment of Radiation Area Dose Rate in Nuclear Medicine Hot Lab during Technetium Generator Elution

**Rowida B. Mehassi [1], Malaz M. Ahmed [2], Fahad A. Mohamed [3], Gamareldin E. Eltayb [4], Mona E. Albasheer [5]**

[1, 2, 3,4]PhD Holder, Radiological Sciences Department, AL-Ghad International College for Applied Medical Sciences, Dammam, KSA
[5]PhD Holder, Radiological Sciences Department, Taif University, KSA

**Abstract:** ***The hot lab is a specially designed room in a nuclear medicine hospital where the radiopharmaceuticals are delivered, stored, and prepared for dispensing. Mo99/Tc99m 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 patient care and minimize radiation exposure to all nuclear medicine personnel, patients, the public, as well as the environment. The descriptive, cross-sectional study design was used to measure radiation area dose rate during elution at different distances with generator days' progress in King Fahad specialist hospital Dammam, using a GM device, which is a gas-filled detector that measure radiation area dose rate in real-time. The dose rate was measured in µGy/hr during the first tenth days at 0.15m, 0.3m, and 0.6m distances from the generator during elution. The study revealed dose rate was decreased with distance increased and generator days' progress. A significant relationship was found between them at $p \geq 0.01$. The inner surface dose rate was also measured at 1m distance from generator in µGy/hr, and the dose rate readings were 0.85,0.30 and 0.20 µGy/hr at the 1st, 5th and 10th day respectively. The outer surface also has been measured at 1m distance away from the hot lab door in µGy/hr, and the dose rate readings were 0.35, 0.15, and 0.10 µGy/hr, at the 1st, 5th and 10th day respectively. The study represents a statistically significant relationship between generator days' progress and the dose rate readings in both the outer and inner surface of the hot lab, at $p \geq 0.01$. Special care should be taken properly in the hot lab, especially at the receipt date of a new generator. Each nuclear medicine facility should be taken ALARA principle properly. The need for growing awareness among all the radiation workers was recommended and encouraging safe working practices in nuclear medicine.***

**Keywords:** 99Mo/99mTc-generators, Geiger Muller device, Hot lab, Nuclear Medicine, As Low As Reasonably Achievable

## 1. Introduction

Nuclear medicine is the medical specialty that uses unsealed sources of radiation liquids and gases. These unsealed sources are known as radiopharmaceuticals, drugs that emit radiation. (U.S. Regulations, 2017)

All the nuclear medicine facilities in the world use some common radionuclide such as Tc99m, I131, Cs137, Sr90, P32, Co57 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. (Akinlade Bidemi O Kelani Sherif, 2018)

For radiation safety issue, nuclear medicine facilities are divided into two parts: controlled area, and 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 the hot lab is an important factor. There are three fundamental parameters that affect staff doses in the radio pharmacy, the distance between the staff member and the source, time spent manipulating the source and the amount of shielding used to reduce the dose rate from the source. (J. Radiate, 2004)

Sometimes there is a trade-off between these parameters as using more shielding might increase handling time. Skill and expertise of the staff carrying out the procedures are also important factors. (IAEA, 1996)

The sources of ionizing radiation exposure should be handled on (ALARA) basis "As Low As Reasonably Achievable" and for that every reasonable effort to maintain exposures to ionizing radiation below the dose limits should be made by improving the hot-lab facility. (ICRP, 1990) Tc99m is used in nuclear medicine frequently, which is generally stored in the hot lab. (Richards P., Tucker W.D., 1998)

The study wants to measure the dose radiation area in the hot lab during Technetium generator elution in king Fahad specialist hospital, Dammam, using GM device which is an area monitoring device using gas filled detector that detect and measure radiation, when it contacts with ionizing radiation, survey instrument respond to the charged particles that are produced because radiation interacts with and ionizes the gas in the detector.

## 2. Literature Survey

The study clearly states the amount of radiation area dose rate in a hot lab during Technetium generator elution using GM device.

## 3. Materials and Methods

### 3.1 Study design

A descriptive, cross sectional study design was used to measure radiation area dose in a hot lab using GM device.

### 3.2 Place and duration of the study

The study was carried out at King Fahad Specialist Hospital, Dammam, KSA and the data were collected in the period spanned from 5 to 15 Jan. 2018.

### 3.3 Data Analyses

The measurement was performed for 10 days, and one Technetium generator was used in the study. The radiation area dose rate measurements were collected in a data sheet that prepared specially for this task. Data analyzed using Microsoft excel and statistical package for the social sciences (SPSS) IBM version 25.

### 3.4 Instruments used

A real time radiation area dose measurements were collected using GM gas filled detector which has a dose rate ranged from 0.05 ^Sv/h - 1 OSv/h and dose ranged from 0.01 ^Sv/h - 10 Sv/h. It was made in Finland by RADOS technology by a serial number of 260048 and the last calibration was done by Standard Secondary Dosimetry Laboratory, Institute of Nuclear Science and Technology, SA in 11.12.2015.

Mo99 –Tc99m generator was used because of their ideal half-life (6 hr) and optimum energy (140 Kev and 90% abundance).

The dose rate was measured in the first tenth days at 0.15m, 0.3m and 0.6m distances from generator during elution.
The inner surface dose rate was measured at 1m distance from generator in μGy/hr and the outer surface was measured at 1m distance away from the hot lab door in μGy/hr.

## 4. Results and Discussion

Radiation cannot be detected by human senses. A variety of instruments is available for detecting and measuring the radiation.

The study clearly states the amount of radiation area dose rate in a hot lab during Technetium generator elution using GM device and the measurements were as follows: the dose rate at the distance from 0.15m from generator in the first five days were ( 25, 22, 17, 13, 10μGy/hr) respectively and from the sixth day to tenth day were (9, 7, 5, 4, 3μGy/hr) respectively and the distance at 0.30m from generator in the first five days were (17, 16, 12, 10, 7μGy/hr) respectively and from the sixth day to tenth day were (6,6,5,3,3μGy/hr) respectively, and the distance at 0.60m from generator in the first five days were ( 7,6,5,4.5, 3.5μGy/hr) respectively and from the sixth day to tenth day were ( 3, 3, 2.5, 2, 1μGy/hr) respectively table (1). So the study confirmed the dose rate was decreased with distance increased, which agree with study done byForså K, Stranden E., 2012. A significant relationship was found between the amount of dose rate at different distances and generator days' progress, at $p \geq 0.01$ table (3).

**Table 1:** Dose rate measurements at different distances from generator during elution with generator day progress

| *Generator day progress* | *Dose rate at different distances from generator during elution in μGy/hr* | | |
|---|---|---|---|
| | *0.15m* | *0.30m* | *0.60m* |
| 1st day | 25 | 17 | 7 |
| 2nd day | 22 | 16 | 6 |
| 3rd day | 17 | 12 | 5 |
| 4th day | 13 | 10 | 4.5 |
| 5th day | 10 | 7 | 3.5 |
| 6th day | 9 | 6 | 3 |
| 7th day | 7 | 6 | 3 |
| 8th day | 5 | 5 | 2.5 |
| 9th day | 4 | 3 | 2 |
| 10th day | 3 | 3 | 1 |

Moreover, the study results that the dose rate at 1m distance from generator (inner door surface of the hot lab) from the first day (receipt day) until 10thday were (0.85, 0.80, 0.55, 0.40, 0.30, 0.30, 0.25, 0.22, 0.22, 0.20 μGy/hr) respectively table (2). The study so emphasized the dose rate was decreased as distance increase and day's progress and this confirmed the study done by J. Radiat, 2004.

The study also noted the dose rate at 1m distance from the hot lab door (outer surface) from the first day (receipt day) until 10thday were (0.35, 0.25, 0.15, 0.15, 0.15, 0.15, 0.13, 0.13, 0.11, 0.10 μGy/hr) respectively table (2).

The study represents a statistically significant relationship between generator days' progress and the dose rate readings in both outer and inner surface of the hot lab, at $p \geq 0.01$, table (4).

**Table 2:** Measurements of dose rate at 1m distance from the inner and outer door surface of the hot lab during elution with generator day progress

| *Generator day progress* | *Inner door surface of the Hot lab in μGy/hr* | *Outer door surface of the Hot lab in μGy/hr* |
|---|---|---|
| 1st day | 0.85 | 0.35 |
| 2nd day | 0.80 | 0.25 |
| 3rd day | 0.55 | 0.15 |
| 4th day | 0.40 | 0.15 |
| 5th day | 0.30 | 0.15 |
| 6th day | 0.30 | 0.15 |
| 7th day | 0.25 | 0.13 |
| 8th day | 0.22 | 0.13 |
| 9th day | 0.22 | 0.11 |
| 10th day | 0.20 | 0.10 |

**Table 3:** Cross tabulation describes the amount of dose rate at three different distances with generator day progress. $P \leq 0.01$**

| *Correlations* | | | | | |
|---|---|---|---|---|---|
| | | *Generator day progress* | *Doserate at 0.15m* | *Dose rate at 0.30m* | *Dose rate at 0.60m* |
| Generator day progress | Pearson Correlation | 1 | -.969** | -.961** | -.982** |
| | Sig. (2-tailed) | | .000 | .000 | .000 |
| | N | 10 | 10 | 10 | 10 |
| Dose rate at 0.15m | Pearson Correlation | -.969-** | 1 | .994** | .984** |
| | Sig. (2-tailed) | .000 | | .000 | .000 |
| | N | 10 | 10 | 10 | 10 |
| Dose rate at 0.30m | Pearson Correlation | -.961-** | .994** | 1 | .983** |
| | Sig. (2-tailed) | .000 | .000 | | .000 |

| | | | | | |
|---|---|---|---|---|---|
| | N | 10 | 10 | 10 | 10 |
| Dose rate at 0.60m | Pearson Correlation | -.982-** | .984** | .983** | 1 |
| | Sig. (2-tailed) | .000 | .000 | .000 | |
| | N | 10 | 10 | 10 | 10 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | |

**Table 4:** Relation between measurements of dose rate at 1m distance from the inner and outer door surface of the hot lab during elution and generator day progress: P≤0.01 **

| *Correlations* | | | | |
|---|---|---|---|---|
| | | *Generator day progress* | *1m from generator (inner surface)* | *1m away from hot lab door (outer surface)* |
| Generator day progress | Pearson Correlation | 1 | -.907-** | -.818-** |
| | Sig. (2-tailed) | | .000 | .004 |
| | N | 10 | 10 | 10 |
| 1m from generator (inner surface) | Pearson Correlation | -.907-** | 1 | .916** |
| | Sig. (2-tailed) | .000 | | .000 |
| | N | 10 | 10 | 10 |
| 1m away from hot lab door (outer surface) | Pearson Correlation | -.818-** | .916** | 1 |
| | Sig. (2-tailed) | .004 | .000 | |
| | N | 10 | 10 | 10 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | |

## 5. Conclusion

Keeping exposure below the radiation protection issue in the hot lab is an important factor and protection must be provided to reduce the over doses that might cause radiation reaction.

Special care should be taken properly in the hot lab, especially at the receipt date of a new generator to keep radiation exposure low. Study emphasized the dose rate was decreased as distance increase and days progress.

## References

[1] Akinlade Bidemi I. Kelani Sherif O. Assessment of Radiation Dose in Nuclear Medicine Controlled Areas: Hot Lab, Injection and Isolated Rooms 2018. 31 [8]: 11-16.
[2] Forså K, Stranden E. Radiation dose to nuclear medicine technicians per unit activity of administrated 99mTc at four Norwegian hospitals. Radiat Prot Dosimetry. 2012;152(4):410-413.
[3] International Atomic Energy Agency, IAEA.. International basic safety standards for protection against ionizing radiation and for the safety of radiation sources. availablefrom. (IAEA).Vienna+(1996).&oq=.(IAEA).Vienna+(1996). &aqs=chrome..69i57.842j0j9&sourceid=chrome&ie=UTF-8 accessed on 1996.
[4] Recommendations of the International Commercial on Radiological Protection, Annals of the ICRP (ICRP60), Vol.21 (1-3), Pergamon Press (New York), 1990
[5] Richards P., Tucker W.D., Srivastava S.C. (1998). Technetium-99m: an historical perspective. Int. J. Appl. Radiat. Isot., 33: 793-799.
[6] J. Radiat. Res.Assessment of radiation dose in nuclear medicine hot lab Iran. 2004; 2 (2): 75-78
[7] U.S. Regulations, Nuclear Medicine: Introduction to U.S. & International Regulations and Clinical Practice Resources: What is Nuclear Medicine? Available from https://libguides.okcu.edu/c.php?g=225265&p=1492819 Accessed in Jan 29, 2017

## Author Photo

**Malaz M. Ahmed**,PhD Holder, Radiological SciencesDepartment, AL-Ghad International, Collegefor Applied Medical Sciences, Dammam, KSA

**Rowida B. Mehassi**,PhD Holder, Radiological Sciences Department, AL-Ghad International,College for Applied Medical Sciences, Dammam, KSA

**Mona E. Albasheer**, PhD Holder, Radiological Sciences Department, Taif University, College for Applied Medical Sciences, KSA

**Gamareldin E. Eltyab**,PhD Holder, Radiological Sciences Department, AL-Ghad International, College for Applied Medical Sciences, Dammam, KSA

**Fahad A. Mohamed,** PhD Holder, Radiological Sciences Department, AL-Ghad International, College for Applied Medical Sciences, Dammam, KSA