VOLUME - 11, ISSUE - 02, FEBRUARY - 2022 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

Original Research Paper

Medical Physics

RADIATION DOSE TO NUCLEAR MEDICINE TECHNOLOGIST DURING MANUAL SYNTHESIS OF HIGH SPECIFIC ACTIVITY NON-CARRIER ADDED LU177 LABELLED RADIOPHARMACEUTICALS

Sarepaka V Ramanamurthy

ABSTRACT

Introduction: Nuclear Medicine technologists are exposed to radiation when doing tasks such as labeling/synthesis of radiopharmaceuticals, radiopharmaceutical administration, scintigraphy and area monitoring. If they are dealing with therapeutic radiopharmaceuticals, radiation exposure could be significantly higher. In this study we are estimated the radiation dose to technologists involved with the synthesis of therapitical radiopharmaceuticals like Lu-177-DOTATATE (DOTA-Tyr3-octreotate) and PSMA-617(Prostate specific membrane Antigen).

AIM: The aim of this study is to calculate the radiation dose to a technologist who is involved in the labelling of two different Lu-177 labelled compounds, namely Lu-177 DOTATATE and Lu-177- PSMA, and also to compare the occupational burden to the dose limits described by India's Atomic Energy Regulatory Board.

Materials and methods: Radiation levels were measured before the start of the labelling procedure in the Radiopharmacy room. An electronic pocket dosimeter given to technologist for instant radiation exposure. 135mci to 520mci of Lu177 used for the labelling procedure. Data were noted for 16 of Lu177-DOTATATE and 13 for Lu177-PSMA.Meantime noted for Lu177-DOTATATE is 52.68min and also 52.39min for Lu177-PSMA.

Mean whole body radiation dose was 0.041 ± 0.004 mSv and 0.037±0.002mSv. Higher dose was obtained during the synthesis of Lu-177 DOTATATE.

Conclusion: Data suggest that during the manual radio labelling of Lu -177radiopharmaceuticals, the whole-body radiation exposure to technologist is within the limits prescribed by AERB.

KEYWORDS :

INTRODUCTION:

Nuclear Medicine technologists are exposed to radiation when doing tasks such as labeling/synthesis of radiopharmaceuticals, scintigraphy and monitoring. When dealing with therapeutic radiopharmaceuticals, the radiation dose could be significantly higher.

Radiation dose received by technologist during the manual synthesis of Lu-177DOTATATE (DOTA-Tyr3-octreotate) and Lu-177-PSMA-617 (Prostate specific membrane Antigen) was noted in this work. The aim of personnel monitoring is to reduce radiation exposure to as low as possible (ALARA). [1]

According to ICRP recommendation 103 (2007), a personnel's effective radiation dosage over five years should not exceed 20mSv, with no more than 50mSv in any single year [2]. As a result, the stochastic chance of radiation impacts will be kept to a minimum.

The aim of the study looked at Nuclear medicine technologist exposure to radiation during the labelling of the DOTATATE (DOTA-Tyr3-octreotate) and PSMA-617(Prostate specific membrane Antigen).

Lu-177 have very good physical and chemical characteristics for imaging and therapy (-max: 497 keV; 1: 113 keV; 6.4 percent and 2: 208 keV; 11 percent); and a long half-life (6.7 days), making it easy to transport from reactor [3].

The most common way for Lu-177 is via 176Lu (n, y)177Lu, whereas the alternative is to irradiate Yb-176 via the reaction 176Yb (n, y)177Yb, with a half-life of 1.9 hours to Lu-177. The second has the advantages that (1) there is no carrier lutetium present, and so is referred to as "no-carrier added" lutetium (NCA Lu-177), and (2) there is no ^{177m}Lu (meta stable) produced, which has a physical half-life of 160 days. Another benefit of the NCA Lu-177 is that it requires less peptide to label the necessary active amount of Lu-177-DOTATATE and Lu-177-PSMA for the therapy.

The specific activity of Lu177 through the indirect method depends on the amount of lutetium in the target. Calculations showed that even if only 4.8mg Lu-177 (0.48% by mass) is created from 1g of target material when irradiated with a high-density neutron flux, the Lu-177 specific activity would be significantly reduced.

Lu-177-DOATATATE, PSMA-617 can both be synthesized by using automatic, semi-automatic and manual method. Manual method is cost effective. So, the technologists involved in the synthesis will be exposed to a higher level of radiation. As a result, the goal of this research is to estimate the total radiation exposure to a technologist during manual labelling of Lu-177radiopharmaceuticals.

MATERIALS AND METHODS:

Lu-177 as $LuCl_3$ was received from ITG, Germany. NCALu-177, the precursors for the synthesis of Lu-177 labelled DOTATATE and PSMA-617 were obtained from ABx GmbH Company, Germany. The research was done over a period of 20 months (Nov 2017 to June 2019).

An Electronic Pocket dosimeter (PDM-117) manufactured by ALOKA company was used to measure the instant radiation dose to technologist. It was calibrated by Nuvia Company India in January 2016 and also recalibrated 2018.A calibrated Survey meter cum contamination monitor (RM-701N) was used during labelling procedure.

Procedure:

Lu-177- DOTATATE and PSMA-617 was labelled at the radio-pharmacy laboratory of the Department of Nuclear Medicine, Mahatma Gandhi Cancer Hospital & Research Institute, Visakhapatnam, Andhra Pradesh India. They were labelled by manual method. A survey cum contamination monitor (RM-701N) was used to measure the background radiation in the Radiopharmacy room before the start of labelling procedure. And also placed it at the location where technologist stands during the procedure. The survey meter was also tested periodically for its accuracy by measuring the radiation exposure rate at 2 meters with I-131standard source. The technologist was used pocket dosimeter before the start of the procedure. Initial reading was set at zero every time. Radiation dose readings were noted on completion of the labelling procedure. The total amount of radioactivity used

during labelling and the duration of each labelling procedure was noted.

Statistics:

statistical analysis was done for the collected data; and mean, median, standard deviation (SD), and range (minimum to maximum value) were calculated and noted, All the readings were expressed as mean ± SD.

RESULTS:

Table1: Radiation Dose During the synthesis of Lu177-PSMA Labelling

S. NO	DATE	Activity (mci)	DURATION (Min)	PRODUCT (mci)	% RCP	RADIATION DOSE (mSv)	EXPOSURE RATE (mSv/Hr)
1	20/11/2017	354	53	351	99.5	0.042	0.06
2	12/02/2018	191	53	175	99.3	0.035	0.05
3	19/03/2018	150	52	144	99.7	0.037	0.04
4	11/04/2018	156	53	143	99.5	0.038	0.04
5	21/05/2018	348	55	325	99.1	0.043	0.05
6	06/06/2018	135	52	130	99.5	0.034	0.04
7	09/07/2018	176	52	170	98.7	0.036	0.04
8	24/09/2018	180	53	177	99.5	0.038	0.04
9	11/03/2019	175	52	165	99.7	0.039	0.03
10	16/04/2019	155	52	147	99.8	0.034	0.04
11	21/05/2019	156	52	150	99.2	0.037	0.04
12	06/06/2019	145	52	135	99.6	0.039	0.03
13	18/06/2019	156	52	150	99.7	0.04	0.04

Table2: Radiation Dose During the synthesis of Lu-177-DOTATATE Labelling.

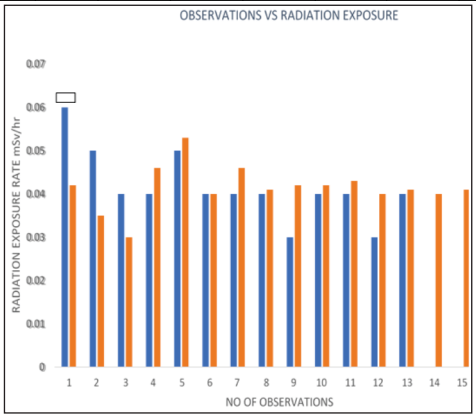
S. NO	DATE	ACTIVITY (mci)	DURATION (Minutes)	PRODUCT (mci)	% RCP	RADIATION DOSE (mSv)	EXPOSURE RATE (mSv/Hr)
1	07/11/2017	320	52	300	99.2	0.042	0.04
2	02/02/2018	220	53	200	99.5	0.035	0.04
3	19/03/2018	190	53	181	99.1	0.03	0.03
4	11/04/2018	446	54	435	99.2	0.046	0.05
5	14/05/2018	520	54	485	99.3	0.053	0.06
6	06/06/2018	145	52	141	99.3	0.04	0.03
7	16/07/2018	370	53	356	99.5	0.046	0.05
8	24/09/2018	295	53	275	99.6	0.041	0.05
9	12/11/2018	183	52	181	99.5	0.042	0.04
10	26/11/2018	181	52	169	99.6	0.042	0.04
11	10/01/2019	146	52	140	99.7	0.043	0.04
12	21/01/2019	165	53	160	99.4	0.04	0.04
13	27/02/2019	265	53	252	99.8	0.041	0.05

The mean whole-body (chest dose) radiation dose noted in Lu-177-DOTATATE labelling was 0.041 ± 0.004 mSv and Lu-177-PSMA-617 was 0.037±0.002 mSv and the meantime of labelling procedure was 52.68min and 52.38 min. The specific activity of Lu-177 was (>3600GBq/mg) receiving in all labelling procedures.

The mean estimated exposure rate during the two labelling procedures was 0.044 ± 0.0089 mSv/hr for DOTATATE and 0.041 ± 0.007 mSv/hr for PSMA-617. Overall mean radiation dose was 0.0425 mSv and duration was 52.53min.

TLD Dose readings (Oct 2017-June 2019)

S.NO	OCT-DEC	JAN-MAR	APR-JUNE	JULY-SEPT	OCT-DEC	JAN-MAR	APR-JUNE
CHEST (mSv)	0.25	0.25	0.95	0.55	0.65	0.7	0.8
WRIST (mSv)	3.8	5.85	6.8	7.55	8.7	6.2	7.1



DISCUSSION:

This research was, aim to estimate the radiation dose levels to technologist in the labelling of ^{177}Lu-labeled radiopharmaceuticals that is DOTATATE and PSMA-617. Labelling method of the two compounds with Lu-177 can be automated/ semi-automated [4,5] or manual. At our department, labelling procedure of these compounds was performed with Lu-177 (NCA) by a manual method and also it is cost effective. We undertook this research to address the radiation safety concerns is higher than that in automated or semi-automated methods [6].

Lu-177(NCA) gives specific activity (>3600GBq/mg) up to 4 to 5 times higher, longer shelf life and also offers efficient radio labelling reaction. It needs low amount of peptide to label the Lu177-radiopharmaceuticals. NCA Lutetium-177 gives the high radio nuclide purity. But carrier added isotope contains up to 0.1 % metastable Lutetium-177m (t1/2= 160.1 days) and requires costly management and storage of contaminated radioactive waste.

Our readings suggest that the mean radiation dose during the labelling was 0.041 ± 0.004 mSv for Lu-177-DOTATATE and0.037±0.002 mSv for Lu-177-PSMA-617.

The reasons for the observed trend in table 1&2 are the time taken for radiolabelling and amount of the radioactivity handled. The highest radiation dose was 0.052 ± 0.0089mSv for Lu-177-DOTATATE (54min&520mCi) and0.043 ± 0.007 mSv for Lu-177-PSMA-617(55 min& 348mCi).

Overall combined mean radiation dose for the two ^{177}Lu-compounds was 0.0425 mSv. Assuming a maximum of 29 such synthesis every year per person, the total mean dose to the personnel involved will be 1.24 mSv.

The reading of the TLD badge of the technologist involved was

also within prescribed limits, that is, for 1 year 2.4mSv for chest badge. It should be noted that the above reading includes the radiation dose to the personnel from other sources as well apart from the radio labelling procedures mentioned in this study. These dose levels are far less than the stipulated AERB limits of 20 mSv/year (averaged over 5 years). The reading of the TLD badge for 1 year was 27.8mSv for wrist badge. This shows that even the manual radio-labelling methods of Lu-177 compounds are safe, provided safe work practices are followed.

CONCLUSION:

This study expresses that manual radio-labelling of Lu-177 radiopharmaceuticals are safe, and that the whole-body radiation dosage to the technologist during labelling procedure is well within the ICRP's recommended limits of 20 mSv/year (averaged over 5 years).

REFERENCES

1. International basic safety standards for protection against ionizing radiation and for the safety of radiation sources. IAEA, Vienna, Austria. Basic safety standards series no. 115
2. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103.Ann ICRP.2007;37:1-332. doi: 10.1016/ j. icrp. 2007.10.003.
3. Pillai MR, Chakraborty S, Das T, Venkatesh M, Ramamoorthy N. Production logistics of 177Lu for radionuclide therapy. ApplRadiatIsot. 2003;59:109–18.
4. Aslani A, Snowdon GM, Bailey DL, Schembri GP, Bailey EA, Pavlakis N, et al. Lutetium-177 DOTATATE production with an automated radiopharmaceutical synthesis system. Asia Ocean J Nucl Med Biol. 2015;3:107–15.
5. Decristoforo C, Simmer D, Wurzer A, Haubner R, Virgolini I, Guggenberg EV. Validation of a cassette based fully automated synthesis of 177Lu-PSMA617. World J Nucl Med. 201514
6. Arora G, Mishra R, Kumar P, Yadav M, Ballal S, Bal C, et al. Estimation of whole-body radiation exposure to nuclear medicine personnel during synthesis of 177 Lutetium-labelled radiopharmaceuticals. Indian J Nucl Med. 2017;32:89–92.