Original Article

Radiation Safety Assessment of 177Lu-DOTATATE Intra-arterial Peptide Receptor Therapy (PRRT)

Abstract

Objective: ^{177}Lu-DOTATATE peptide receptor therapy (PRRT) is an established treatment for patients suffering from neuroendocrine tumors. In the last few years, intra-arterial PRRT is being considered for patients having liver metastatic disease predominantly. The aim of our study is to measure the radiation doses received by the treating intervention radiologists involved in intra-arterial PRRT treatment using ^{177}Lu-DOTATATE. **Materials and Methods:** Radiation safety-related data of 31 patients who underwent 177Lu-DOTATATE intra-arterial PRRT treatment were used for this study. The exposure rate was measured at the hand and eye and chest level of treating intervention radiologists continuously from the beginning to the end of the administration. Exposure from the patient at the body surface (at the level of liver, thigh, and extremities) and 1 m from the body surface was measured just after the administration. The mean radiation exposure from the patient at the body surface and 1 m from the body was also calculated. **Results:** The mean administered activity was found to be 194 (±17) mCi. The mean radiation exposure at the surface at the level of the liver, thigh, and feet and at 1 m from the surface was found to be 100 (±25.11), 9 (±1.27), 5.6 (±0.52), and 5.3± (0.50) μSv/hr, respectively. The mean administration time was found to be 23 ± 5.6 min. The mean radiation dose to the hands, and eyes, of the treating intervention radiologist per procedure, was found to be 6.425 ± 2.75 μSv, 5.43 ± 1.76 μSv and 1-m exposure from the patient was found to be 5.3 ± 0.246 μSv, respectively. **Conclusion:** Our result shows that the radiation exposure from the patient postadministration is below the permissible limit of discharge. The radiation exposure to the intervention radiologist is also suggestive of a safe procedure to be performed by maintaining the radiation dose well within the permissible limit for radiation professionals.

Keywords: *^{177}Lu, ^{177}Lu-DOTATATE, intra-arterial, neuroendocrine tumor, peptide receptor therapy*

Manoj Kumar Hariram Chauhan[1,2], Ashish Kumar Jha[3,4], Sneha Mithun[3,4], Rutuja Dasharath Parab[3,4], Pooja Dwivedi[1,2], Ameya D Puranik[3,4], Kunal Bharat Gala[2,4], Nitin Sudhakar Shetye[2,4], Suyash Kulkarni[2,4], Venkatesh Rangarajan[1,3,4]

[1]Department of Nuclear Medicine and Molecular Imaging, Advanced Centre for Treatment Research and Education in Cancer, Tata Memorial Centre, Departments of [2]Radiology and [3]Nuclear Medicine and Molecular Imaging, Tata Memorial Centre, Tata Memorial Hospital, [4]Homi Bhabha National Institute, Mumbai, Maharashtra, India

Address for correspondence:
Dr. Venkatesh Rangarajan, Department of Nuclear Medicine and Molecular Imaging, Tata Memorial Centre, Tata Memorial Hospital, Dr. Ernest Borges Road, Parel, Mumbai - 400 012, Maharashtra, India.
E-mail: drvrangarajan@gmail.com

Received: 02-08-2023
Revised: 15-12-2023
Accepted: 19-12-2023
Published: 18-11-2024

Access this article online

Website: https://journals.lww.com/ijnm

DOI: 10.4103/ijnm.ijnm_88_23

Quick Response Code:

Introduction

Neuroendocrine tumors (NETs) growing worldwide and they are basically originated from cells of the endocrine and nervous systems. NET is rare and it can be found anywhere in the body but most commonly occurs in the intestine and is also found in the pancreas, lungs, and the rest of the body.[1] There are different types of NETs some grow slowly and some grow very rapidly. Somatostatin receptors (SSTRs) are commonly expressed in NETs and these receptors belong to the superfamily of G-protein-coupled receptors. SSTRs have five subtypes SSTRs1–SSTRs5.[1,2] In a NET, mostly, SSTRs are overexpressed at SSTR site 2 (SSTRs2). Peptide receptor therapy (PRRT) is a molecular-targeted radiation therapy binding the overexpressed receptors on tumors with high affinity and specificity. DOTATATE peptide has a high affinity toward the SSTRs2.[1-4]

^{177}Lu-DOTATATE PRRT is an established treatment for patients suffering from NET because of ^{177}Lu having good theranostic properties and its availability at large scale and at regular intervals. ^{177}Lu having a long half-life of 6. 647 days and beta energy 498 Kev (78.6%), 384 Kev (9.1%), and 176 Kev (12.2%). Average beta energy 134 Kev. ^{177}Lu having also two gamma energy E^{γ} = 208 keV (11.1%), 113 Kev (6.6%). ^{177}Lu has an average range in soft tissues (~0.23 mm or 0.023 cm) and a maximum range in soft tissue of 1.8 mm (0.18 cm). HVL for gamma photon of ^{177}Lu is 0.6 mm (0.06 cm) and TVL is 2.1 mm (0.21 cm) and HVL for betas (Plexiglas) is 1.35 mm (0.135 cm) gamma-ray constant of Lu177 is 0.28 mR/h/mCi at 1 cm.[5-8]

In the last few years, intra-arterial PRRT is being considered for patients having

How to cite this article: Chauhan MK, Jha AK, Mithun S, Parab RD, Dwivedi P, Puranik AD, *et al.* Radiation safety assessment of 177Lu-DOTATATE intra-arterial peptide receptor therapy (PRRT). Indian J Nucl Med 2024;39:254-8.

predominantly liver metastatic disease.[9] From a radiation safety point of view, special precaution or attention is required when dealing with intra-arterial PRRT therapy at the same time also minimizing the radiation absorbed dose to intervention radiologists.[9-11] The radiation safety in nuclear medicine procedures becomes paramount as the open liquid radiation source is handled during the procedure.[12-17] In PRRT therapy, the major portion of radiation exposure is involved at the time of the dose administration process concerning the intervention radiologists who perform the procedure which is studied thoroughly.[18-21] In our study, we aim to assess radiation safety compliance of the procedure, the radiation exposure from the patient, and also the radiation exposure to the intervention radiologists involved in the injection process in the intra-arterial PRRT treatment using ^{177}Lu-DOTATATE.

Materials and Methods

Radiation safety-related data of 31 patients who underwent ^{177}Lu-DOTATATE intra-arterial PRRT treatments were used for this study. The prescribed activity around 200 mCi of ^{177}Lu-DOTATATE dose was dispensed by the nuclear medicine technologist using CRC-25 Beta Dose Calibrator, Capintec Inc, NJ USA. RAM GENE Survey cum Contamination Monitor, Rotem Industry, Israel, was used for all the surveys and contamination monitoring performed in this study. The entire method is described below [Figure 1].

Dose preparation

For each patient, two-unit doses of 100 mCi or required in 10 ml syringe were dispensed.

Doses were kept in a syringe shield and immobilized on the transfer trolley covered with a green plastic sheet and absorbent sheet.

Surface and 1-m dose rate from the syringe shield-containing radioactivity was measured and recorded.

Dose transportation to intervention radiology

Doses in the syringe shield were transported to intervention radiology [Figure 2].

The lift that was used to transport the doses was evacuated before transport.

Dose administration (intra-arterial)

The entire place and equipment are covered with green plastic sheets and absorbent paper.

The expert intervention radiologist with more than 10 years of experience placed a microcatheter at the tumor-feeding vessel in the liver.

Three-way valve was connected to avoid any backflow from the microcatheter.

Both doses were administered intra-arterially through microcatheter by the intervention radiologist.

The exposure rate was measured at the hands, eyes, and chest level of treating intervention radiologists continuously from the beginning to the end of the administration. The exposure rate was noted in the radiation safety data sheet.

After administration of radiopharmaceutical, 20 ml saline chase was given followed by contrast agent to ensure the proper wash of the microcatheter.

Residual activity and waste collection

Postadministration, both the syringes were kept in the respective syringe holders, the microcatheter was removed and kept in a waste container with a plastic sheet and the other syringes were used during the procedure.

Waste was contained properly in the shielded waste container.

Waste container dose measurement was taken and recorded.

Patient survey

Exposure from the patient at the body surface (at the level of liver, thigh, and extremities) and 1 m from the body surface was measured after the administration.

Final survey and contamination monitoring

Postadministration, we monitored intervention radiologists and other staff to check for any contamination.

Transport and storage of waste in the nuclear medicine department (HDT) waste storage room

Waste was labeled properly as per the radiation safety guidelines transported back to the nuclear medicine

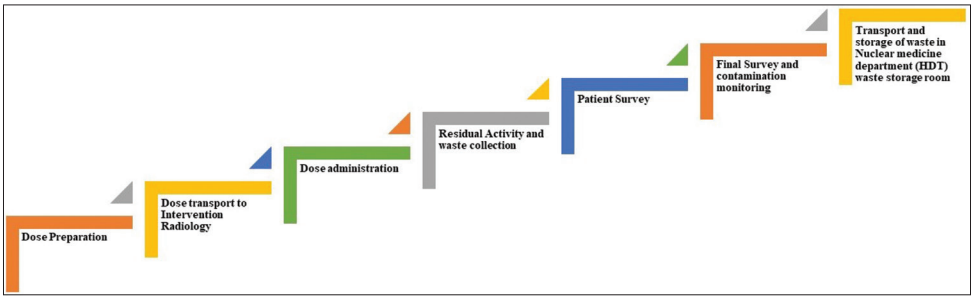

Figure 1: The entire processes involved in intra-arterial radionuclide therapy of Lu-177-DOTATATE intervention radiology

department and kept in a waste storage room for decay for a sufficient time.

Subsequently, west disposal was performed in accordance with stipulated radiation safety guidelines by the Atomic Energy Regulatory Board (AERB).[22]

Mean exposure calculation

The mean radiation exposure per procedure to the eye, hand, and whole body to the treating intervention radiologist was calculated. Finally, the exposure to the hand, eye, and whole body of the treating intervention radiologist was calculated by multiplying the mean exposure rate by the time of administration. The mean radiation exposure from the patient at the body surface and 1 m from the body was also calculated.[13-15]

Results

The mean administered activity was found to be 194 (±17) mCi. The mean surface and 1-m dose rate from the transfer container were found to be 0.18 (±0.02) uSv/hr and 0.028 (±0.0008) uSv/hr, respectively [Figure 3]. The mean radiation exposure at the surface at the level of the liver, thigh, and extremities and at 1 m from the surface of the patient is given in Table 1 and Figure 4. The mean radiation exposure to the hands, eyes, and whole body to the treating intervention radiologist per procedure is 5.8 ± 3.6, 4.0 ± 3.1, and 1.8 ± 1.3 uSv, respectively [Figure 5 and Table 2]. On every occasion, we were able to transfer the radioisotope without any problems from the nuclear medicine department to the intervention radiology department. A few times, the intervention radiologist's gloves were found to be contaminated; nevertheless, upon removing the gloves, the hand was clean. There was never any evidence of surface, equipment, or person contamination. We did not experience any problems with the microcatheter's backflow because the three-way valve was utilized to prevent it.

Discussion

^{177}Lu-DOTATATE PRRT is an established treatment for patients suffering from NETs. In the last few years, intra-arterial PRRT is being considered for patients having liver metastatic disease predominantly. From a radiation protection purpose or safety point of view monitor, the dose received by the treating intervention radiologists and check it is within the prescribed annual dose limits.[11,14,22] The critical group that gets exposure from ^{177}Lu-DOTATATE intra-arterial therapy is an intervention radiologist.[16-19] In this study, we measured the exposure rate at the hand and eye, and chest level of treating intervention radiologists continuously from the beginning to end of the

Figure 2: Setup for transportation of radiopharmaceutical from Nuclear Medicine Department (high dose therapy ward) to intervention radiology department; (a) radioactivity transport trolley, (b) syringe carrier, (c) syringe shield

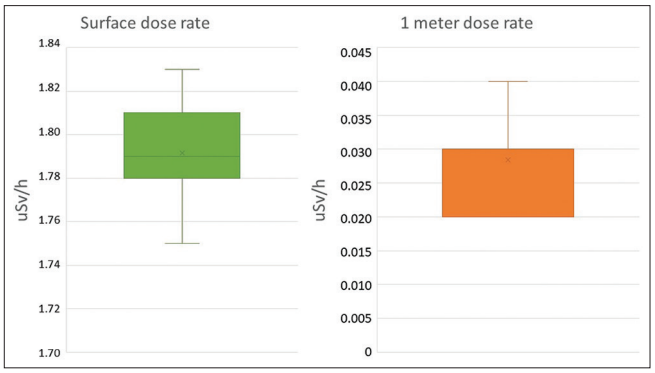

Figure 3: The box plot shows the surface and 1-m dose rate from the transfer container

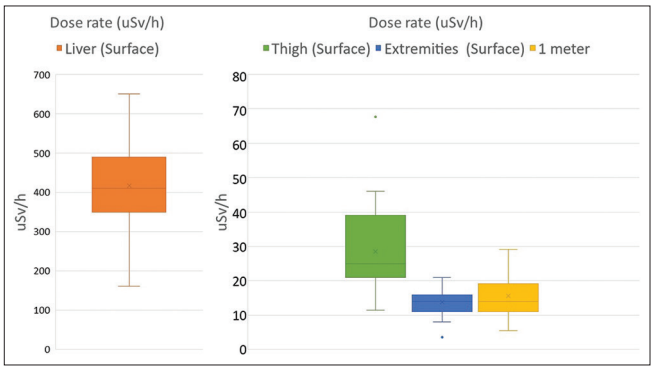

Figure 4: The box plot shows the average dose rate on liver surface, thigh surface, and extremities (foot) surface and 1-m dose rate from the injected patients

Table 1: The average radiation exposure rate from the patient after administration of Lu-177-DOTATATE at a 1-m distance from the surface, as well as the surface dose at the level of their liver, thighs, and foot (extremities)

	Surface dosage rate from the patient after administration			
	Liver	**Thigh**	**Feet**	**1 m**
Mean radiation exposure (μSv/h)	416.7±115.1	29.1±12.3	14.1±3.6	16.0±5.5
Mean administered activity (mCi)		194±17		
Mean administration time (min)		23±10		

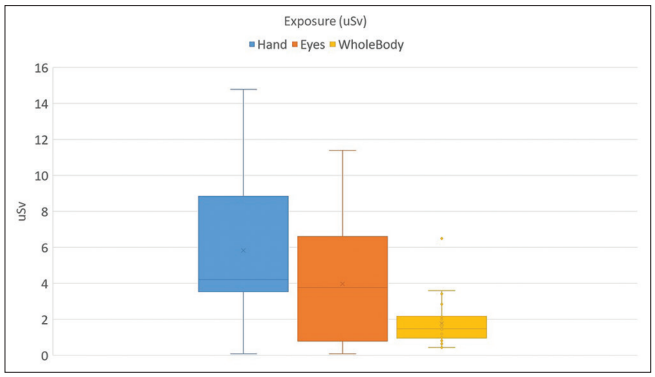

Figure 5: The box plot shows the total exposure to the hand, eyes, and whole body of an intervention radiologist

administration and also measured the exposure from the patient at the body surface (at the level of liver, thigh, and extremities) and 1 m from the body surface after the administration of the therapeutic dose of ^{177}Lu-DOTATATE.

By adhering to the radiation safety protocol, we successfully completed the intra-arterial PRRT treatment. No noncompliance was discovered during the process. We did not experience any problems with the microcatheter's backflow because the three-way valve was utilized to prevent it. It was discovered that the intervention radiologists' radiation exposure was substantially under the permissible limit. The exposure to the hand, and eye, of the treating intervention radiologists was calculated by multiplying the mean exposure rate by the time of administration also found to be well within the permissible limit. The mean radiation exposure from the patient at 1 m from the body found to be 1.6 ± 0.55 μSv/hr. The 1-m dose rate from the patient in our study was found to be consistent with that of Kim K *et al.*[4] Intra-arterial Lu-177 DOTATATE delivery and systemic treatments were found to take about the same amount of time overall.[14-21] A few times, the patient's symptoms persisted for longer periods, therefore, the intraarterial administration was given for longer periods of time. Sulieman A *et al.*[6] have found the annual radiation dose of 0.5–1.5 mSv to the staff taking care of Lu-177-DOTA therapies. In our study, the intervention radiologist will get a similar dose if they perform 250 therapies in a year and the external radiation exposure shows a similar result.

Our study shows that the 1-m radiation exposure from the patient postadministration is below the permissible limit of discharge. The radiation exposure to the intervention radiologists is also suggestive of a safe procedure to be performed by maintaining the radiation dose well within the permissible limit for the radiation professional which is prescribed by the national competent authority (AERB).[22]

Conclusion

Our study shows that the radiation exposure from the patient postadministration is below the permissible limit of discharge. The radiation dose to the intervention radiologists is also suggestive of a safe procedure to be performed by maintaining the radiation dose well within the permissible limit for the radiation professionals which is prescribed by the national competent authority (AERB). Good work practices at the time of ^{177}Lu-DOTATATE intra-arterial therapy using a proper shielding device such as a syringe shield and protective gloves (double) may reduce the exposure to the treating intervention radiologists during the ^{177}Lu-DOTATATE intra-arterial therapy. Overall, intra-arterial Lu-177-DOTATATE therapy is a safe procedure from the radiation safety point of view.

Table 2: Radiation exposure to the interventional radiologist expressed as mean and standard deviation

	Hands	Eyes	Whole body
Mean radiation dose (μSv/h)	6.425±3.16	5.55±2.20	5.75±2.40
Mean administered activity (mCi)		200±24	
Mean administration time (min)		23±10	

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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