Radiation Dose Assessment Around Patients in Single Photon Emission Computed Tomography Units During Bone scintigraphy and DTPA Renogram

[1]Bahalul Hasan, [1]Md. Sunny Anam Chowdhury, [1]Sujon Mahmud, [1]Fariha Zerin, [1]Yeasmin Akter, [1]Nazmul Hossain, [2]Faruk Hossain, [3]M Rubel Alamin, [4]Masud Parvej, [5]Selim Reza

[1]Institute of Nuclear Medicine & Allied Sciences, Kushtia
[2]Institute of Nuclear Medicine & Allied Sciences, Bogura
[3]Institute of Nuclear Medicine & Allied Sciences, Pabna
[4]Institute of Nuclear Medical Physics, Savar, Dhaka,
[5]Physical Science Division, Bangladesh Atomic Energy Commission, Dhaka

Correspondence Address : Bahalul Hasan, Scientific Officer, INMAS, Kushtia, Kushtia Medical College & Hospital Campus, Kushtia -7000.
Email: bhaasan26@gmail.com

ABSTRACT

Introduction: During imaging with Single Photon Emission Computed Tomography (SPECT) units, ionizing radiation is emitted by a patient's body after being injected with radiopharmaceuticals (Rph). Radiation protection as well as knowledge of safe regions around the working environment is essential for nuclear medicine (NM) occupational workers. The present study measured the dose rate at different points around the Rph-injected patients with different activities of ^{99m} Tc-DTPA for renograms and ^{99m}Tc-HDP for bone scans, the two most common imaging procedures in the SPECT units of NM establishments.

Patients and Methods: This study was carried out in the scintigraphy division of the Institute of Nuclear Medicine and Allied Sciences (INMAS), Kushtia, where 52 male patients were included. Out of the 52 patients, DTPA renogram was done in 26, aging between 1 and 69 (mean = 30.8) years, and bone scan was done in 26, aging between 29 and 71 (mean = 38.8) years. Patients received a dose of 2-5 mCi for the DTPA renogram and 20 mCi for the bone scan with the Mediso SPECT-CT gamma camera unit. The dose rates were measured pragmatically by using a ranger survey meter around radioactive patients in different locations in SPECT-CT units.

Result: During contact with radioactive patients, the occupational exposure increases but significantly decreases by increasing distance, as well as the dose rate reduces greatly with respect to time. This study observed that radiation dose was very low at 1 m distance from the radioactive patient.

Conclusion: The SPECT/CT occupational worker should remain at a distance of more than 1 m from the radioactive patients and carry TLD batches and wear lead shield aprons for their safety.

Keywords: ALARA principle, Diethylenetriamine pentaacetate, Thermo Luminescent Dosimeter

Bangladesh J. Nucl. Med. Vol. 28 No. 1 January 2025
DOI: https://doi.org/10.3329/bjnm.v28i1.79542

INTRODUCTION

Nuclear medicine (NM) is an advanced medical specialty that uses radioactive substances to diagnose and treat diseases by focusing on organ function, offering unparalleled sensitivity in detecting abnormalities, often before structural changes are visible (1). Unlike conventional radiology, which uses external radiation sources like X-rays, nuclear medicine captures radiation emitted from within the body, known as "endoradiology". Key modalities include Single Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET), with SPECT being particularly effective for creating 3D images that integrate both functional and anatomical data (2). By utilizing a radioactive isotope with tracer that emits gamma rays, SPECT provides insights into organ functions such as blood flow, brain activity, and bone disorders, and, when combined with CT (SPECT-CT), offers enhanced precision for diagnosis and treatment planning (3). The rapid adoption of SPECT technology in Bangladesh across both government and private hospitals highlights its growing role in early disease detection and management, underscoring the need for stringent radiation safety protocols for patients and healthcare professionals.

This study aims to improve the safe and effective use of SPECT by ensuring compliance with international safety guidelines and implementing optimal operational standards (4). The focus is on maintaining radiation exposure within acceptable limits, ensuring routine quality control for accurate diagnostics, and enhancing safety protocols to protect both patients and radiation occupational workers.

PATIENTS AND METHODS

The study was conducted in the Institute of Nuclear Medicine and Allied Science (INMAS), Kushtia to assess the radiation exposure in and around post injected patients during dynamic renograms and static bone scans performed by SPECT.

A total of 52 male patients was included, 26 had undergone DTPA renograms and the other 26 ^{99m}Tc-HDP bone scans. Demographic characteristics like age, weight, height along with and prescribed doses are presented in Table 1 and 3, respectively. Confidentiality was strictly maintained.

The ^{99m}Tc radioactive isotope, a pure gamma emitter, was intravenously injected into the patients, with an average dose of 5 mCi combined with DTPA for renal imaging and 20 mCi with HMDP for bone imaging. Scans were then performed immediately for dynamic renograms and 120 minutes post-injection for static bone scans.

Once the scan commenced, the data of radiation level at various points around the SPECT room was measured by a radiation survey meter (Ranger Radiation Alert Monitoring-200). Eleven specific measurement points, as outlined by the IAEA guidelines, are designated for radiation monitoring (5). Point 1 is positioned directly below the detector when it is placed at the 0-degree position. The detector rotates around the patient, capturing gamma ray projections. Radiation levels are recorded at each of the 11 points, which are strategically located around the SPECT room, including areas of potential exposure to both patients and healthcare professionals. The data collected is used to evaluate radiation safety and ensure compliance with international safety standards.

RESULTS AND DISCUSSIONS

The study evaluated patient details, radiation dose measurements, and scan readings for DTPA Renogram and Bone Scan procedures using SPECT technology. Table-1 presents demographic and procedural data for patients undergoing DTPA Renograms, offering a comprehensive overview of case distribution and clinical patterns. Table-2 and Figure 1 focuses on radiation dose assessments for DTPA Renogram patients, emphasizing the importance of maintaining safe exposure levels.

Table 1: Data for DTPA renogram patient details

Sl	Age (y)	Weight (Kg)	Hight (cm)	Dose (mCi)
Min	1	9	73	2
Max	69	82	176	5
Avg	30.8	48.16	136	4.32

Table 2: Radiation dose around DTPA renogram patients

	Point (µSv/h)													
Sl	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Control Room**	**Corridor**	**Outside Room**
Min	5.70	0.18	0.20	0.28	0.18	0.18	0.16	0.07	0.22	0.22	0.16	0.11	0.13	0.12
Max	12.63	0.34	0.82	1.47	0.51	0.78	0.65	0.98	0.47	0.44	0.39	0.23	0.29	0.23
Avg	8.96	0.25	0.41	0.74	0.26	0.36	0.27	0.51	0.32	0.28	0.25	0.17	0.21	0.17
SD	2.01	0.04	0.14	0.31	0.08	0.17	0.10	0.21	0.06	0.04	0.06	0.04	0.04	0.03

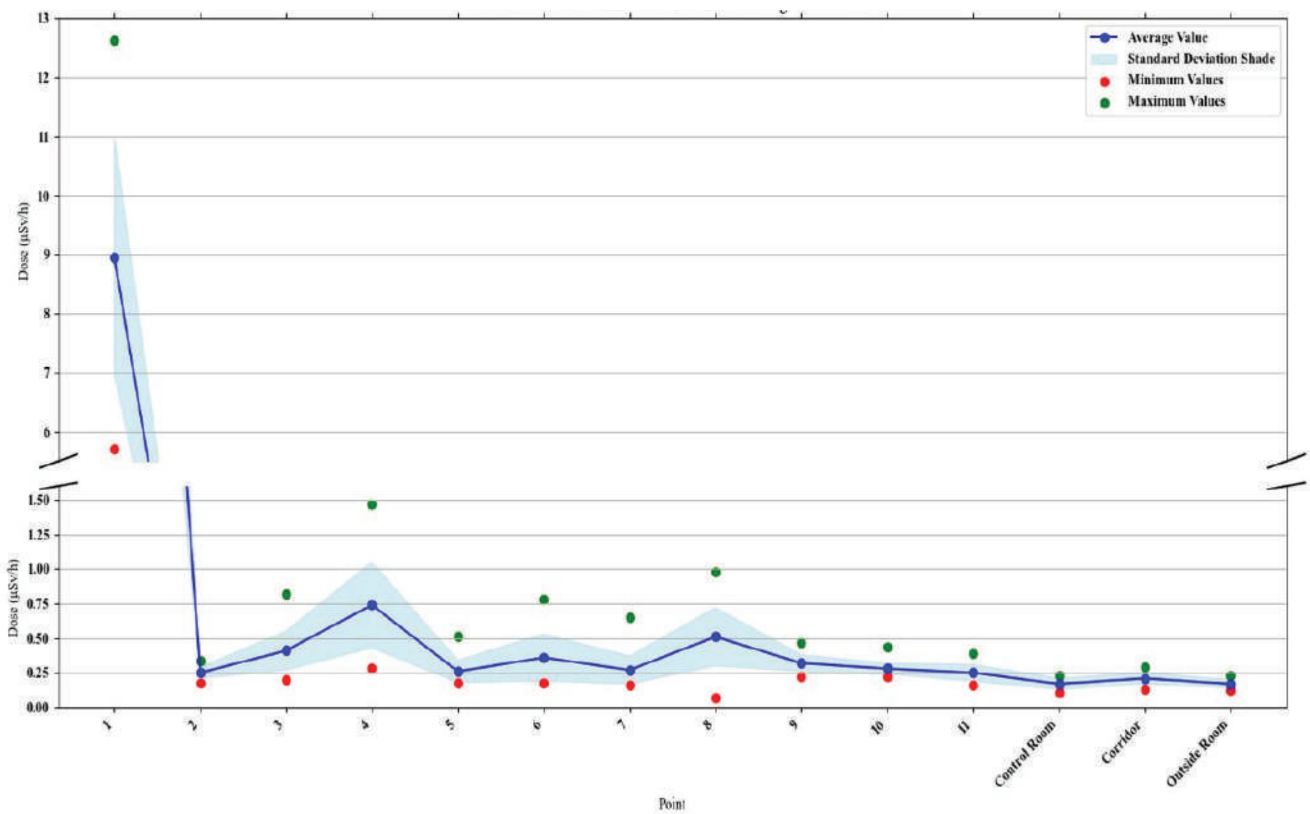

Figure 1: Radiation Dose Assessment around DTPA Renogram Patients

Table-3 highlights patient details specific to Bone Scan procedures, including demographic and procedural insights. Table-4 and Figure 2 assesses the radiation doses surrounding Bone Scan patients, underlining the necessity of dose monitoring to enhance safety while ensuring diagnostic accuracy.

Table 3: Demographic details of the 99mTc-HDP bone scintigraphy patients

Sl	Age(y)	Weight (Kg)	Hight (cm)	mCi
Min	29	9	73	20
Max	71	82	176	20
Avg	30.8	48.16	136	20

Table 3: Demographic details of the ^{99m}Tc-HDP bone scintigraphy patients

	Point (µSv/h)													
Sl	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Control Room**	**Corridor**	**Outside Room**
Min	11.20	0.20	0.22	0.56	0.20	0.23	0.21	0.56	0.21	0.12	0.13	0.11	0.12	0.12
Max	35.10	0.43	0.63	1.90	0.56	0.65	0.61	1.40	0.48	0.33	0.34	0.25	0.36	0.35
Avg	21.02	0.29	0.32	1.14	0.34	0.32	0.32	0.80	0.34	0.25	0.24	0.15	0.22	0.21
SD	7.27	0.05	0.08	0.44	0.09	0.11	0.09	0.21	0.08	0.05	0.04	0.04	0.07	0.07

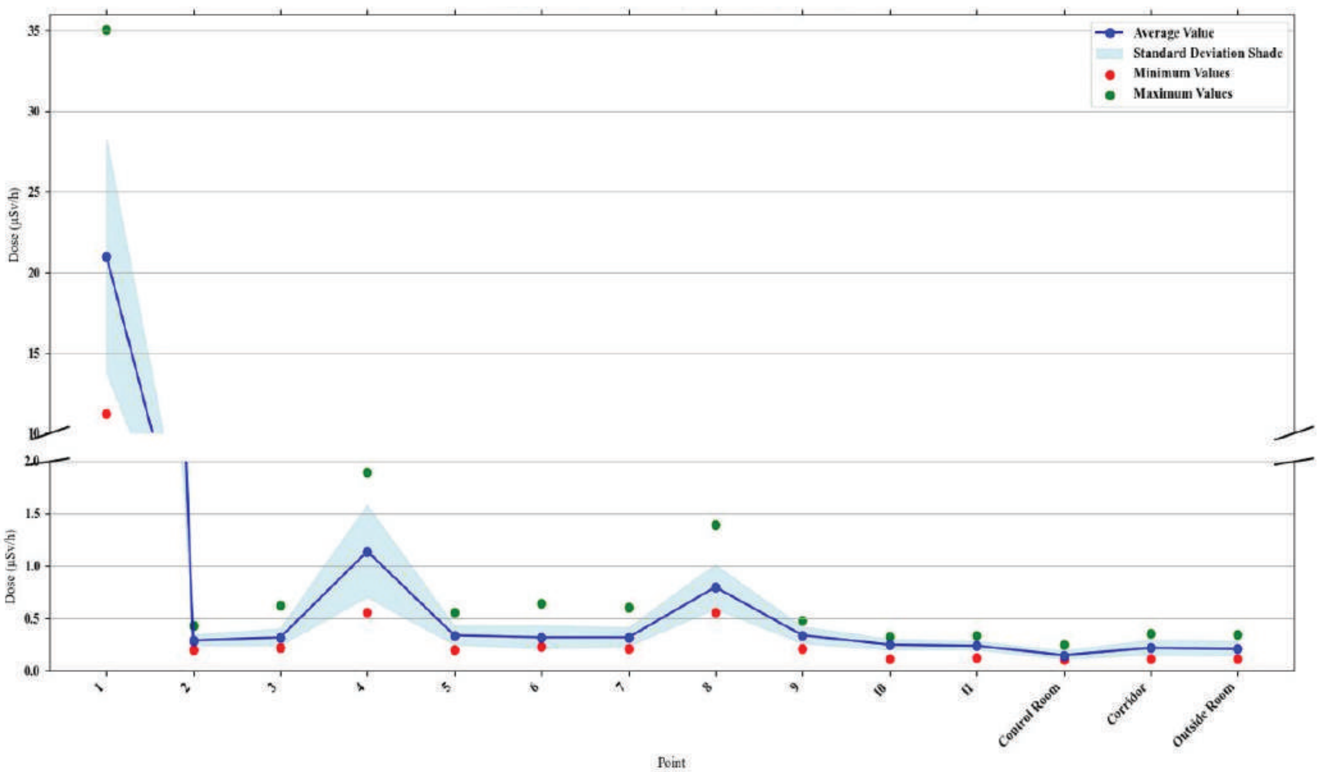

Figure 2: Radiation Dose Assessment around Bone Scan Patients

During contact with radioactive patients the occupational exposure increases but significantly decreases by increasing distance as well the dose rate reduces greatly with respect to time. The measured dose rate in the SPECT bunker split into 4 different areas respectively public area, Supervised area, Controlled area and Uncontrolled area. In Figure 4, public area which starts from 0-0.5 in where safe points are 2, 5, 9, 10, 11 and corridor, control and outside of the room considered as safe zone. In supervised area that starts from 0.5-3 where measured points are 3,

4, 6, 7, 8. In controlled areas start from 3-10 and in Uncontrolled areas starts from more than 10, where measurable points are 1.

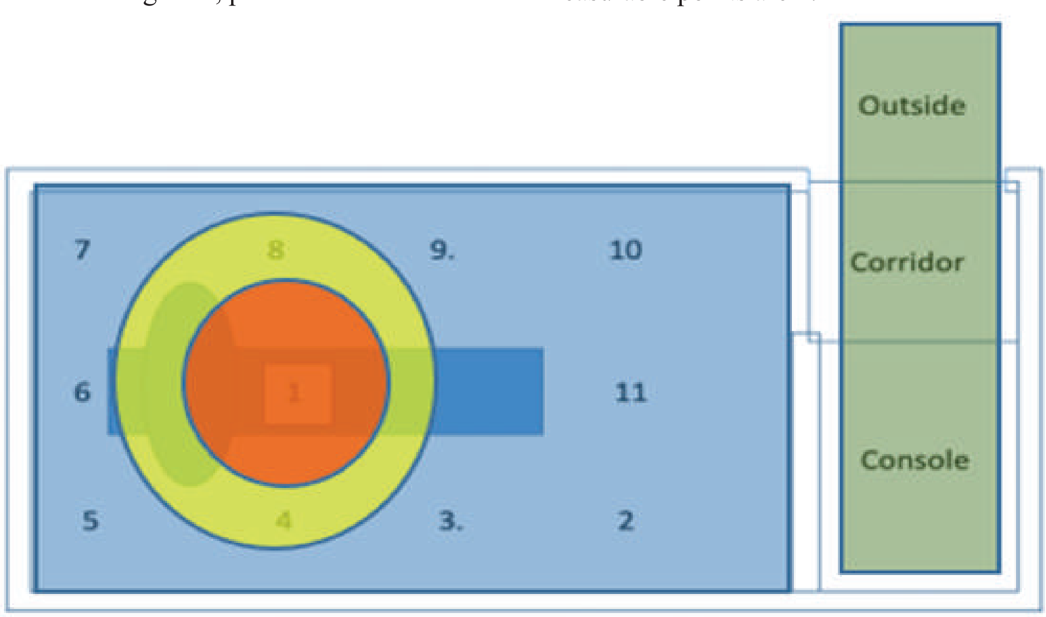

Figure 4: Locations of the specified points in SPECT room

This study highlights the diagnostic role of SPECT/CT scans, particularly in bone scans and DTPA Renograms, emphasizing the importance of radiation protection measures such as minimizing exposure time, maintaining safe distances, and using protective gear like lead aprons and TLD badges for occupational workers (6). Future advancements could focus on developing acceptance tests for SPECT/CT's component in Bangladesh, enhancing its utility in fields like cardiology and molecular medicine. Despite technical limitations, such as the lack of laser alignment systems, SPECT remains cost-effective and essential for nuclear medicine.

CONCLUSION

Since awareness and standardized protocols develop, SPECT/CT has the potential to significantly enhance healthcare outcomes in Bangladesh, the SPCET/CT occupational worker should remain at a distance more than 1m from the radioactive patients and carry TLD batch and wear lead shield aprons for their safety.

DECLARATION

Conflicts Of Interest: Authors have no conflicts of interest regarding this case report. All images were used with informed consent of the patient and these images are not for distribution in the electronic media for further use.

REFERENCES

1. Rahman, A, Salam, F, Begum , R, Akhter, A, Nabi, S. Rahman, M. K, Quraishi, F. A.(2018). Functional Neuroimaging: Single Photon Emission Computed Tomography (SPECT) In Neurological Disorders. Bangladesh Journal of Neuroscience, 34(2), 96–105.
2. Kaneta T. PET and SPECT imaging of the brain: a review on the status of nuclear medicine in Japan. Jpn J Radiol. 2020 Apr;38(4):343-357. doi: 10.1007/s11604-019-00901-8. Epub 2020 Feb 10. PMID: 32043236.
3. Spiliotopoulou, Maria, Papathanasiou, Nikolaos, Labieniec, Lukasz, Andreas, Apostolopoulos. 99mTc-DTPA dynamic SPECT/CT renogram in adults. Feasibility and diagnostic benefits. DOI: 10.21203/rs.3.rs-3799428/v
4. International Atomic Energy Agency, Quality Assurance for SPECT Systems, IAEA Human Health Series No. 6, IAEA, Vienna (2009)
5. Crișan G, Moldovean-Cioroianu NS, Timaru DG, Andrieș G, Căinap C, Chiș V. Radiopharmaceuticals for PET and SPECT Imaging: A Literature Review over the Last Decade. Int J Mol Sci. 2022 Apr 30;23(9):5023. Doi: 10.3390/ijms23095023.
6. Sharma P, Sharma S, Ballal S, Bal C, Malhotra A, Kumar R. SPECT-CT in routine clinical practice: increase in patient radiation dose compared with SPECT alone. Nucl Med Commun. 2012 Sep;33(9):926-32. doi: 10.1097/MNM.0b013e328355b6d5