Journal of Associated Medical Sciences 2021; 54 (3): 73-77

JAMS
Journal of Associated Medical Sciences

Thai-Journal Citation Index Centre (TCI) & ASEAN Citation Index (ACI)

Journal of Associated Medical Sciences

Journal homepage: https://www.tci-thaijo.org/index.php/bulletinAMS/index

# Radiation emitted from patients undergoing nuclear medicine examination at Udonthani Cancer Hospital

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**ARTICLE INFO**

*Article history:*
*Received June 2021*
*Received in revised form June 2021*
*Accepted as revised July 2021*
*Available online July 2021*

*Keywords:*
*Nuclear medicine, radiopharmaceutical, radiation protection*

**ABSTRACT**

**Background**: Diagnostic nuclear medicine involves intravenous injection of radiopharmaceutical substances into the patient, after which they still possess the substance within their bodies and depict mobile radiation sources. Although the amount of radiation emitted is little and harmless to others, practitioners in and outside the Division of Nuclear Medicine along with related personnel and relatives of the patient are anxious about radiation exposure from a patient undergoing nuclear medicine examination.

**Objectives**: This study aimed to measure radiation doses from the patients at different times and distances.

**Materials and methods**: The radiation dose was measured from 66 patients (19-79 years) undergoing bone scan, MUGA scan, and thyroid scan. The data were collected at different times intervals and different distances from the patients.

**Results**: The results showed that the radiation dose from patients after a bone scan and MUGA scan at a distance less than 0.50 meter was higher than 10 µSv/hr, which is the radiation exposure limit of the practitioner.

**Conclusion**: Results of this study are helpful in operation planning such as increasing the distance and reducing the time of close contact, which can ease anxiety of concerned personnel, while radiation practitioner training as well as educating patients and relatives must be carried out to encourage better understanding.

## Introduction

Udonthani Cancer Hospital began providing diagnostic nuclear medicine services with a single photon emission computed tomography (SPECT) in December 2019. In the year 2020, there were a total of 1,248 patients which were 1,137 cases of bone scan, 50 cases of multi -gated acquisition scan (MUGA scan), 47 thyroid scans, and 14 parathyroid scans. Nuclear medicine examination is a diagnostic test that uses a radioactive unsealed radionuclide source labeled with a pharmaceutical compound called radiopharmaceuticals which is administered into the patient intravenously. Selection of the radiopharmaceuticals is based on the diagnostic techniques such as $^{99m}$Tc-methylene diphosphonate (MDP) for bone scan, $^{99m}$Tc-phytate for gastrointestinal (GI) study or solid gastric emptying scintigraphy, and $^{99m}$Tc-pertechnetate for cardiac and thyroid scans. Radiation emitted from the patient is measured and utilized to create images to diagnose function of the organs of interest. After the examination, patients still contain the radioactive substance within their bodies and depict mobile radiation sources, although the amount of radiation emitted by the patient's body is small and harmless to others,[1-3] which does not exceed the radiation exposure limit; below 1 millisievert per year (mSv/y) for

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**doi:**
**E-ISSN:** 2539-6056

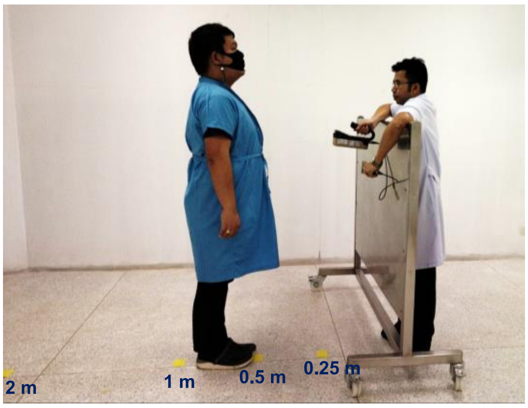
general public, and below 20 mSv/y (or 10 µSv/hr) for technical practitioners. Generally, the radiation dose emitted from the patient decreases with increasing period of time.[4] Therefore, increasing the distance between the patient and other persons[1] along with the use of radiation shielding devices to reduce the radiation dose are recommended. Several studies have observed the radiation dose to occupational radiation workers (i.e. technician, radiologist, nurses in nuclear medicine services)[5] and non-occupational radiation workers (accompanying nurses, relatives, other staffs and patient)[6-8] from nuclear medical procedures. The results indicated that there is no need to quarantine patients for the radioactive decays. Except in some circumstances, such as being away from children and pregnant woman or traveling long distances by public transport.[7, 8] However, practitioners, both in and outside the Division of Nuclear Medicine along with accompanying persons and relatives of the patient are anxious about radiation exposure from a patient undergoing nuclear medicine examination. This is because after nuclear medicine examination, some patients may be required to proceed with other diagnosis such as ultrasound, electrocardiogram or other laboratory tests, as well as commuting by public transport or private vehicle where the patients can radiate radioactivity towards relatives or people in the surroundings.

The Division of Nuclear Medicine, Department of Diagnostic Radiology and Nuclear Medicine, Udonthani Cancer Hospital has never recorded and conducted the study of the radiation dose emitted by the patients before. Therefore, this study aims to measure the radiological radiation dose from patients undergoing nuclear medicine examination at different periods of time and varied distances from the patients. The results of this study shall determine the radiation dose from the patient emitted into the environment, and notify the operating practitioners, as well as inform the patients along with their relatives in order to encourage the awareness of preventive measures and avoid radiation exposure.[3]

## Materials and methods

This is a surveillance study that measured radiation dose emitted from the patients which has been approved by the Human Research Ethics Committee under project number UCH-CT 12/2563. Dose rate measurements were recorded from 66 patients. The patients had a range of age (19-79 years), weight (34-79 kg) and body mass index (BMI) [17-28 kg/m$^2$]. The data were collected from patients undergoing bone scan (n=56), MUGA scan (n=8), and thyroid scan (n=2) over a period of 2 months, from 1 November 2020 to 31 December 2020 (Ethic approval from Human Research Ethics Committee under project number UCH-CT 12/2563).

Using a calibrated survey meter with pancake GM probe, Ludlum model 3000 (Ludlum Measurements, Inc., Sweetwater, Texas). Radiation dose rate was measured from the external surface of abdominal region of the patients at varied distances of 0.25 m, 0.50 m, 1.00 m, and 2.00 m for each interval (Figure 1).

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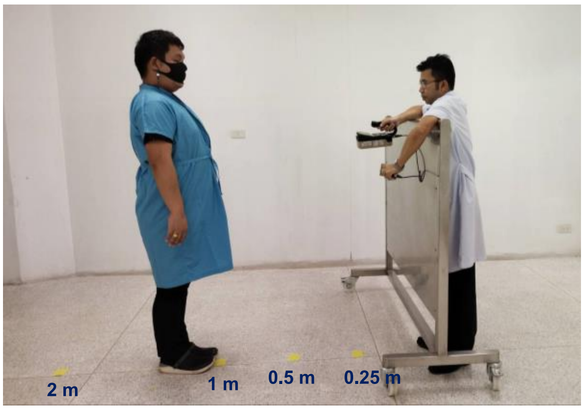


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***Figure 1***. *Radiation dose measurement at varied distances (A) 0.50 m (B) 1.00 m.*

Since, all three scans use different protocols, the waiting time to radiation measurement are not the same as shown in Table 1. Patients undergoing bone scan would receive 20 mCi of $^{99m}$Tc-MDP and wait for 3 hrs to allow accumulation of the radiopharmaceutical around the bone before undergoing a SPECT scan. During the 3 hrs waiting time, radiation dose measurement was measured from the patients at three intervals after injection of the radiopharmaceuticals; immediate (0 hr), 1 hr, 2 hrs, and 3 hrs.

MUGA scan using modified in-vivo ($^{99m}$Tc-pertechnetate) technique. Patients were injected stannous 1.5-2.0 ml intravenously. After 20 minutes, patients were intravenously administered with 20 mCi $^{99m}$Tc-pertechnetate. Patients undergoing MUGA scan have to wait for 20 minutes to allow accumulation of the radiopharmaceutical around the cardiac muscle. Radiation dose rate was measured from the patients immediately (0 hr) after the injection. Then the patients underwent SPECT scanning for about 15-20 minutes. After imaging, the patients were asked to wait for another 20 minutes in the waiting room for the dose rate measurement at 1 hr after injection.

Patients undergoing thyroid scan would receive 3 mCi of $^{99m}$Tc- pertechnetate and radiation dose measurement was measured immediately after injection. Then after 15 minutes waiting for radiotracer accumulation in thyroid, patients would undergo a SPECT scan.

**Table 1** Time of radiation dose measurement from patients undergoing nuclear medicine examination.

| Examination | Radioactivity | Waiting time for SPECT scan (minutes) | Time of measurement after radiotracer injection (hrs) | | | |
|---|---|---|---|---|---|---|
| | | | 0 | 1 | 2 | 3 |
| Bone Scan ($^{99m}$Tc-MDP) | 20 mCi | 180 min | / | / | / | / |
| MUGA ($^{99m}$Tc-pertechnetate) | 20 mCi | 20 min | / | / | N/A | N/A |
| Thyroid scan ($^{99m}$Tc-pertechnetate) | 3 mCi | 15 min | / | N/A | N/A | N/A |

*N/A: not available*

## Results

During the data collection period of 2 months in the Division of Nuclear Medicine, Udonthani Cancer Hospital, a total of 66 patients aged between 19-79 years old underwent nuclear medicine examination; 56 cases of bone scan, 8 cases of MUGA scan, and 2 cases of thyroid scan. Table 2 shows the radiation dose emitted from patients undergoing nuclear medicine examination at various distances and times of measurement.

Results of the radiometric measurements from patients undergoing bone scan showed that after the injection of $^{99m}$Tc-MDP by a mean dose of 20.2 mCi was administered, we found the maximum radiation dose of 58.8±9.0 µSv/hr at a distance of 0.25 meters and it decreased to 5.0±0.5 µSv/hr at 2.00 meters distance. It was found that the radiation dose was higher than 10 µSv/hr when the distance from the patient was less than 1.00 meters. Also, the radiation dose was still higher than 10 µSv/hr when measured 3 hrs after the injection of radiopharmaceuticals was administered at the distance less than 0.50 m (Figure 2).

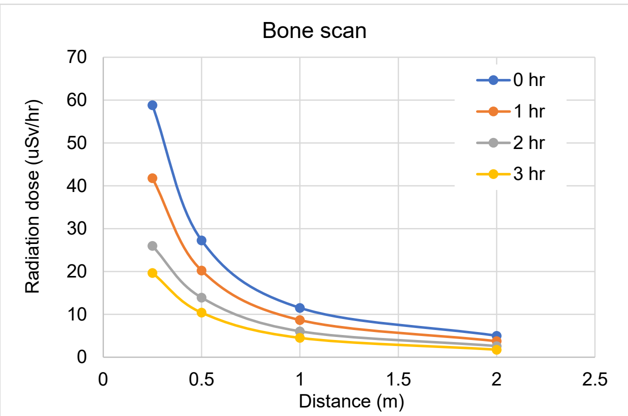


***Figure 2**. Radiation dose of bone scan patients at different distances immediately and every 1 hr after injection of the radiopharmaceuticals.*

The radiation dose emitted from patients undergoing MUGA scan showed the maximum radiation dose of 57.1±9.8 µSv/hr after the injection of a mean dose of 20.1 mCi was administered. $^{99m}$Tc- pertechnetate measured at a distance of 0.25 meters, which decreased to 5.1±0.5 µSv/hr at 2.00 meters distance. It was found that the radiation dose emitted from the patient decreased to below 10 µSv/hr when measured 1 hr after the injection at more than 1.00 meters distance (Figure 3).

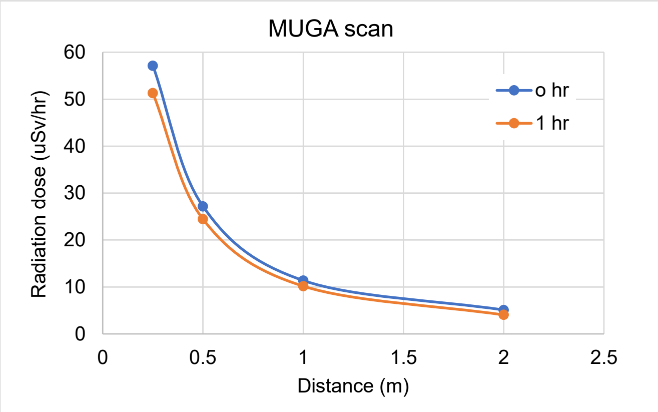


***Figure 3**. Radiation dose of MUGA scan patients at different distances immediately and every 1 hr after injection of the radiopharmaceuticals.*

The radiation dose emitted from patients undergoing thyroid scan showed the maximum radiation dose of 10.0±0.2 µSv/hr after the injection of a mean dose of 3.4 mCi was administered. $^{99m}$Tc- pertechnetate measured at a distance of 0.25 meter and decreased to 0.9±0.1 µSv/hr at 2.00 meter distance (Figure 4).

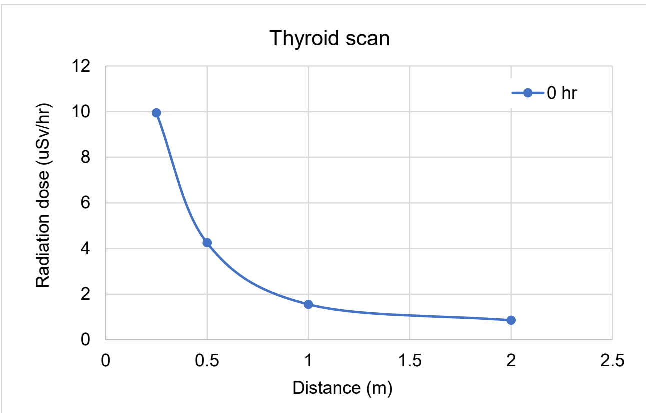


***Figure 4**. Radiation dose of thyroid scan patients at different distances immediately after injection of the radiopharmaceuticals.*

**Table 2** Radiation dose measured in µSv/hr immediately after injection of the radiopharmaceuticals was administered at different distances.

| Examination | N | Radioactivity (mCi) | µSv/hr (mean±SD) | | | |
|---|---|---|---|---|---|---|
| | | | 0.25 m | 0.50 m | 1.00 m | 2.00 m |
| Bone Scan ($^{99m}$Tc-MDP) | 56 | 20.2 | 58.8±9.0 | 27.3±4.3 | 11.5±1.5 | 5.0±0.5 |
| MUGA ($^{99m}$Tc-pertechnetate) | 8 | 20.1 | 57.1±9.8 | 27.2±3.7 | 11.4±1.1 | 5.1±0.5 |
| Thyroid scan ($^{99m}$Tc-pertechnetate) | 2 | 3.4 | 10.0±0.2 | 4.3±0.1 | 1.6±0.1 | 0.9±0.1 |

## Discussion

In this study, the radiation doses were measured from patients undergoing nuclear medicine examination to diagnose various diseases. Different diagnostic protocols use different radiopharmaceuticals with different radiation strengths, where high-intensity protocols increase the radiation dose emitted from the patients when measured at different times and distances. In clinical, the radiation did not meet the inverse square law. The relevant factors such as biological distribution, bone metastases, and urinary excretion.[4] Results from this study are consistent with the previous works[1, 3] and the radiation protection principles. The reduction of exposure time, the increase of distance, and the use of shielding devices when exposed to the source of radiation. These can be applied as a protection against radiation hazards for nuclear medicine practitioners. The findings from this study are helpful for the assessment and planning of operations in the Division of Nuclear Medicine. Radiation dose emitted from patients should be regularly monitored to provide a database that can be used to assist protection planning against radiation hazards. In addition, training of practitioners on radiation hazard prevention as well as the importance of the radioprotection principle "As Low As Reasonably Achievable (ALARA)" is mandatory to promote a work culture that concerns radiation hazards.

Provision of information and operational guidelines can reduce the anxiety of related staff of other departments in the hospital who require close contact with patients undergoing bone and MUGA scans. There should be a minimum distance of 0.50-1.00 meter from the patients while waiting for services along with the close contact time as short as possible in order to maintain a safe radiation exposure limit within 10 µSv/hr. On the other hand, the radiation dose emitted from patients undergoing thyroid scans is within the safe limits for operational practitioners due to lower radiation strength with decreasing physical and biological half-lives. Hence, practitioners of other departments can perform their duties with the patient safely. Radiological technician or staffs who are responsible for patient positioning at a distance less than 0.50 meter should spend as little time as possible to minimize radiation exposure.

Meanwhile, patients undergoing bone and MUGA scans should be informed about radiation emission from their bodies that may be harmful to those around them, because the emission of radiation dose immediately after injection of radiopharmaceuticals is high. Therefore, patients should sit and wait in the provided area or isolated room to reduce radiation exposure to others, which includes providing information on practices for patients after the examination. Since the radiation dose at a distance less than 0.50 meter is still higher than 10 µSv/hr, the patient must have at least 0.50 meter distance from others and avoid holding or being close to children because they are more susceptible to radiation hazards.

Moreover, relatives of close care for the patients undergoing nuclear medicine examination should keep a distance from the patient and use telephones to communicate with the patient to reduce radiation exposure. In case of unavoidable circumstances such as a journey in the same vehicle or use of public transportation, the patient may be allowed to wait for another 1-2 hrs before departure so as to let the radioactivity to decay.

## Conclusion

The radiation dose from the patient after a bone scan and MUGA scan at a distance less than 0.50 meter is still higher than the radiation exposure limit of the practitioner. Hence practitioners, relatives, and the patient themselves should be informed and aware of this emission in order to prevent harmful radiation. The findings derived from this real-world data can be used to develop the standard operating procedure which is suitable for our center. As a result, it would strengthen the radiation safety management for the hospital accreditation. This could be practiced by increasing the distance and reducing the time of close contact, while training and educating practitioners on radiation dose will enhance better understanding and reduce anxiety at work.

## Acknowledgement

The authors thankfully acknowledge Udonthani Cancer Hospital for the support of facilities and helps. Special thanks of the ethical writing guidance to Research Publishing and Academic Support, Udonthani Cancer Hospital.

## Conflict of interest

There are no conflicts of interest to disclose.

**Ethic approval**

Human Research Ethics Committee under project number UCH-CT 12/2563

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