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Assessment of Diagnostic Reference Levels for Dual Bed-Position CT Acquisition in Tc-99m MDP SPECT/CT

Mutiarani Novanti Wibisono[1], Wahyu Setia Budi[1], Ngurah Ayu Ketut Umiati[1], Rini Sintawati[2], Raras Hanifatunnisa[2]

[1]Department of Physics, Faculty of Science and Mathematics, Universitas Diponegoro, Semarang, Indonesia,
[2]Department of Nuclear Medicine and Molecular Theranostics, Dr. Hasan Sadikin General Hospital, Bandung, Indonesia,

Corresponding Author: Mutiarani Novanti Wibisono

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ABSTRACT

The radiopharmaceutical Tc-99m MDP is currently used for bone scans. This examination uses whole-body scans of SPECT/CT to detect bone metastatic and diagnostic. The patient will receive the amount of radiation exposure that is affected by the variations in acquisition parameters. Therefore, determining the DRL is necessary to ensure the dose used is within the optimal limit and in accordance with clinical practice. This study aims to determine the local DRL value for the CT modality in double-bed position SPECT/CT examinations. This study was conducted retrospectively by collecting data on CTDIvol, DLP, and scan length (SL) from patients who were undergoing examinations at Hasan Sadikin General Hospital. The DRL value for the double-bed position was calculated using the 75th percentile of the DLP distribution. The results showed that the use of a double-bed position protocol yields a DLP value twice that of the single-bed position protocol. Confirming that the increase in CT dose is greatly influenced by the contribution of increasing the number of bed positions. These findings indicate the need for protocol standardization and periodic DRL evaluation.

Keywords: DLP, DRL, Double–bed, Bone scan, Tc-99m MDP

INTRODUCTION

A SPECT/CT (Single Photon Emission Computed Tomography/Computed Tomography) scanner is a hybrid imaging modality that combines CT for anatomical marking and SPECT for functional imaging. Bone scan scintigraphy is one of the examination types of SPECT/CT that uses the radiopharmaceutical Tc-99m MDP. Bone scan examinations offer significant diagnostic advantages, but they increase patient exposure. This is because the accumulation of two sources of radiation exposure, gamma radiation from the radiopharmaceutical and X-ray radiation from CT [1].

Technical parameters or exposure factors in CT modality can influence the dose given to the patient, such as voltage (kVp), current (mAs), pitch factor and scan area length (SL) (cm). In general examination, a single-bed position SPECT/CT scans are performed using a scan length of around 40-45 cm because they only cover anatomical areas such as the head, neck, chest, abdomen, and pelvis [2]. However, a longer scan length is required for the pelvic-lumbar anatomical area. The required scan length is around 70-

90 cm or a double-bed position. This will result in a higher DLP value (mGy.cm) compared to the single-bed position.

The DLP is a parameter that describes the total radiation energy/dose received by the patient throughout the scanned body. The DLP value is linear to the CTDIvol (mGy) value and the SL [3]. The higher the CTDIvol and SL values, the greater the DLP value. This value will affect the bone scan examination Diagnostic Reference Level (DRL) value. The DRL refers to the optimal dose level of investigation that balances radiation dose and image quality. However, this value is not used as a dose limit but only to identify unnecessary practices [4].

While double-bed imaging has been widely used, particularly for diagnostic purposes, DRL calculations specifically for double-bed bone scans have not been performed. Therefore, this study will present the CTDIvol and SL distribution values associated with the double-bed position protocol and calculate the DRL value for DLP CT for SPECT/CT Tc-99m MDP imaging with a double-bed position.

MATERIALS & METHODS

This study was conducted retrospectively at Hasan Sadikin General Hospital, Bandung, Indonesia. The data used were patient data who underwent bone scans using the Tc-99m MDP between May and September 2025. Only a limited number of patients underwent the double-bed position examination, so only 35 patients were collected. Data were obtained from a single SPECT/CT machine and were acquired using a dual gamma camera. The CT modality used a low-dose mode, which is generally used for attenuation correction. Patient data collected included CTDIvol, DLP, Scan Length (SL), and patient demographic data such as age, gender, weight, and radiopharmaceutical activity as additional variables.

Statistical Analysis

The DRL value is determined from the 75th percentile (Q3) of the DLP distribution. In addition, the 25th percentile is calculated as the achievable dose level, and the 50th percentile (Q2) as the typical dose. The analysis is carried out descriptively using tables and graphs of the CTDIvol and DLP distributions to determine the DRL.

RESULT

Based on data from 35 patients, the average demographic data is shown in Table 1. Eighteen of the patients who underwent the examination were women and 17 were men. Based on the average age and weight, most patients were elderly with typical adult weight.

Table 1 Demographic Patient Data

Parameter	mean	min	max
Age (Year)	64 ± 15	30	100
Weight (kg)	55 ± 7	41	72
Radiopharmaceutical Activity (MBq)	763 ± 95	507	1029

Overall, the CT parameters that most influenced CTDIvol and DLP values were voltage and current. To obtain the dose parameter values in Table 2, the examination was performed using a voltage of 140 kVp and a current of approximately 20-50 mAs. Other parameter values were kept uniform across all patients. This study used a double-bed position, resulting in an average scan length of 77.5 cm.

Table 2 CT Dose Parameter

Dose Parameter	minimum	maximum	mean	P25	P50	DRL
CTDIvol (mGy)	2.52	4.42	3.85 ± 0.46	3.65	4.03	4.12
DLP (mGy.cm)	194.7	341.6	298.5 ± 35.9	282.6	762.2	817.7

DISCUSSION

The DRL value is obtained as a reflection of the general dose used in the double-bed position protocol for SPECT/CT examinations. The results show that the DRL value in this protocol is greater than that in the single-bed position, especially in the DLP value. The CTDIvol value does not change because it only depends on technical parameters, while the DLP value depends on the CTDIvol and SL values. Where the DLP is the multiplication of the CTDIvol value and SL. The higher the CTDIvol and SL values, the higher the DLP value [5]. This is also illustrated by the graph in Figure 1, both of which have a linear relationship.

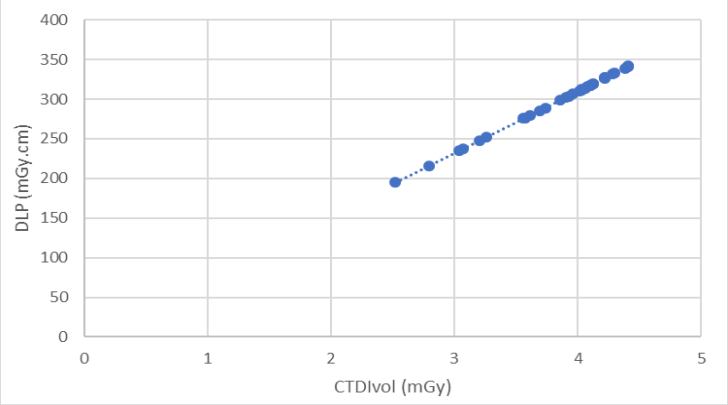

Figure 1 Relation of CTDIvol to DLP

In theory, increasing the number of beds means extending the scanning area. This extension will lead to an increase in dose for several reasons. Increasing the DLP value affects the DRL value, resulting in a higher DRL. Furthermore, extending the scanned area also increases the total SPECT acquisition time, which may contribute to higher cumulative gamma-radiation exposure from the radiopharmaceutical, although the magnitude of this effect is smaller than that of CT and depends on decay and clearance dynamics of the tracer [6]. This will occur even if the radiopharmaceutical activity remains constant. In addition to the DRL, increasing the number of beds also affects the effective dose due to variations in the anatomy being scanned, resulting in a higher effective dose.

Using the double-bed position will result in an increased dose, but due to the length of the scanned area, anatomical coverage is broader. Therefore, this protocol is generally used not only for attenuation correction but also for diagnostic purposes. A higher dose increases sensitivity in detecting lesions. [7].

CONCLUSION

This study has calculated the DRL value for SPECT/CT bone scan examination with double-bed position using Tc-99m MDP. The DRL value is obtained from the 75th percentile of the DLP distribution. The result showed that the use of a double-bed position produces a higher DLP value than a single-bed position. This DRL value is used to determine the local DRL in the nuclear medicine service of Hasan Sadikin General Hospital and can be used as a reference for optimizing CT protocols.

Declaration by Authors

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