Available online www.ejaet.com

European Journal of Advances in Engineering and Technology, 2020, 7(11):15-19

Research Article ISSN: 2394 - 658X

Preliminary Study Determination of Diagnostic Reference Level (DRL) Value Based on the Body Mass of the Patient on Bone Examination of SPECT Modalities of Nuclear Medicine Based on Dose Data of Si-INTAN Patients

Nisa Goti Trishabti[1], Zaenal Arifin[1], Rusmanto[2] and Ida Bagus Gede Pratama[1]

[1]Physics Department, Faculty of Science and Mathematics, Diponegoro University, Semarang, Indonesia-50275
[2]Nuclear Energy Regulatory Agency of Indonesia
zaenalarifin@fisika.fsm.undip.ac.id

ABSTRACT

Diagnostic Reference Levels (DRLs) is one of the efforts to apply radiation protection that is dose optimization for patients in diagnostic measures, one of which is nuclear medicine diagnostics with SPECT modality. Giving a dose toa patient in nuclear medicine is based on the body mass of the patient. BAPETEN provides a web-based application (Si-INTAN) to collect, store, and process patient dose data to determine local and national DRL values. This study aims to analyze the influence of the patient's body mass on the administration of radionuclide activity by determining the median value (Q2) for each patient's body mass interval, determining the local DRL value and the accumulative effective dose received by the patient using the Q_2 value of each hospital and the national DRL value uses the 75 percentile (Q_3) value for all survey data collected on Si-INTAN in 2017-2018. This study produces an analysis that only the "C" hospital follows the procedure in administering radionuclide activity based on the patient's body mass, confirmed by a determination value (R^2) of 0.96. Local DRL values for each hospital were 799.20 MBq, 761.83 MBq, and 584.23 MBq respectively. The effective dose that the patient receives accumulatively at each hospital is 15.18 mSv, 14.47 mSv, and 11.10 mSv respectively. The National DRL value for bone examination with Nuclear Medicine SPECT modality is 791.80 MBq.

Key words: DRL, Local DRL, National DRL, Nuclear Medicine, SPECT, Radionuclide Activity, The Body Mass of Patients, Effective Dose

INTRODUCTION

BATAN (National Nuclear Energy Agency of Indonesia) uses radionuclides for diagnostics and therapy in radiopharmaceuticals. Radiopharmaceuticals play an important role in the development of current and future medicine. Radiopharmaceuticals for diagnostics were developed to imaging various organs with nuclear medical equipment such as SPECT and PET. While radiopharmaceuticals for therapy using monoclonal antibodies and peptides have been shown to give results [6].

Radiopharmaceuticals are radioisotopes that have chemical compounds as identifiers for organs. Radioisotopes emit radiation, which are used to detect the location of the target and the identification compound determines the organ to be examined. Radiopharmaceuticals for diagnostics are carried out by inserting the radiopharmaceutical into the patient's body by inhalation through the inhalation route or by mouth or by injection (in vivo). For diagnostic activities, the ideal radiopharmaceutical is the radiation emitted easily detected with a short half-life as a form of radiation protection and the resulting image quality is optimal [17]. Besides the benefits, radioisotopes can cause radiation effects so that radiation protection is required in their use. To implement radiation protection in Indonesia, BAPETEN as a supervisory body provides a web-based application, namely Si-INTAN or Patient Dose Data Information System as a container to assist in collecting, storing, and managing and retrieval of patient data from health service agencies registered as users in the applicationandas a form of monitoring of dosing to patients, especially in diagnostic measures [4].

The administration of radionuclide doses in nuclear medicine examinations needs to consider the approximate value of radionuclide activity given to the patient's body mass. The patient's body mass is a representation of the thickness that affects the rate of radionuclide activity. In the management of nuclear medicine DRL which is expressed in units of $MBq.kg^{-1}$, it is used as a form of evaluation of the use of nuclear medicine facilities in hospitals by following per under applicable protocols [1, 15].

Previous research has discussed the preparation of paediatric DRL based on body mass on the Anterior-Posterior (AP) chest thorax examination with a general radiographic modality based on the Si-INTAN database which states that the incorporation of body mass in paediatric patients affects the ESAK value as an opportunity to reduce the occurrence of biological effects [16].

Diagnostic Reference Level (DRL)

The term DRL was first used by the ICRP in Publication No. 73 of 1996 to provide radiation protection recommendations in diagnostic radiology installations. The DRL value is not a limiting value but an optimization measure in radiation protection. Optimization does not use the DRL value performed on individual patient examinations but uses examinations in a group of patients obtained from the examination survey result with the same procedure [12]. The DRL value is divided into two parts based on region, namely the local DRL value used to show the DRL value at the hospital and the National DRL value which shows and as an additional measure in assessing the performance of a country's health services [15]. The determination of the DRL value uses the 3^{rd} quartile value of the distribution of 75% of the survey data [9]. The DRL value is used to optimize image quality and the dose given to patients. The local DRL value owned by the hospital does not exceed the National DRL value which has been determined as an investigative tool to optimize diagnostic measures [15].

Patient Dose Data Information System (Si-INTAN)

The Si-INTAN application is used by BAPETEN to monitor the administration of patient doses used in the preparation of DRL values both locally and nationally. The output of the SI-INTAN application was made and developed that Indonesia has a patient dose profile for each type of diagnostic radiology examination as an effort to implement one of the principles of radiation protection, namely optimization [5].

Radiation Doses in Diagnostic Nuclear Medicine

The activity of radionuclides in nuclear medicine diagnostic procedures inserted into the patient's body produces a radiation dose from the body as a radiation source. The dose received by the patient does not have a dose-limiting value at the time of diagnostic action. However, the value of the dose given is still regulated based on the patient's body mass in nuclear medicine diagnostics, referring to the implementation of the risk protection principle to produce an optimal and ideal image [1, 15]. Radiation given to each target organ or tissue will result in different risks depending on the radiation source given refers to the concept of equivalent dose to the organ or target T. The weight factor of radiation on the tissue performed in diagnostic nuclear medicine tests as a multiplier of the average absorption dose will be 1. In other words, the mean equivalent dose in the organ or tissue is equal to the mean absorption dose [13].

The stochastic effect resulting from radiation application to the patient's body is shown numerically as an effective dose. The effective dose in nuclear medicine examination is numerically equal to the average dose equivalent to the organ or tissue because the relative radiation sensitivity values are considered one unit [13]. The radionuclide activity received by the patient introduced into the body as an equivalent dose value will affect the type of radiation, the half-life, and metabolism of the radionuclide [18]. The total equivalent dose calculation applies the calculation for the organs received for 50 years after the radionuclide has been introduced into the patient, using equation (1).

$$H = I(\tau)\ x\ e(\tau) \quad (1)$$

where H is the total equivalent dose with SI units, namely sievert (Sv), $I(\tau)$ is the activity given to the patient is a function of time in SI units, namely, becquerel (Bq) and $e(\tau)$ is the effective dose coefficient is a function of time in units $Sv.Bq^{-1}$. Each radionuclide has a different effective dose coefficient value, at Tc-99m, the effective dose coefficient value is $1.9 \times 10^{-11} Sv.Bq^{-1}$ [10, 14]

RESEARCH METHODS

This research consisted of several stages, the data collection stage was carried out from March to April 2019 with 623 data. The bone examination with Tc-99m MDP pharmaceutics using SPECT for imaging data were usedin this research. The tools and materials used in this study included Microsoft Office Excel 2010 software and a laptop with 4GB RAM. Survey data compiled from the Si-INTAN application from 2017 to 2018, which contains information on patient weight, radionuclides used, and radionuclide activity grouped by the hospital, then the type of examination at each hospital. The age of patients was not included in this research.

Presentation of Data in Graphs

In presenting data in graphs, it is carried out in several stages, namely calculating the median value (Q) and making graphs using Microsoft Office Excel. The survey data has been grouped by type of examination, sorted from smallest to largest body mass. To make it easier to graph the relationship between the patient's body mass and radionuclide activity. The 10 data patients were the minimum number of patients for each weight range to analyse median value. The patient's body mass data is presented in intervals with a range of 10 at each interval, while the radionuclide activity values use the median (Q) value for each body mass interval with formulas available in Microsoft Office Excelor in equation (2).

$$Q = MEDIAN\ (A) \tag{2}$$

where Q is the median value of radionuclide activity for each interval and A is the value of radionuclide activity in MBq. The median values of radionuclide activity and body mass intervals obtained at each hospital are then presented in the form of bar graphs and graphs with a linear trendline of the relationship between the patient's body mass and radionuclide activity.

Effective Dosage Calculations

The resulting effective dose was the cumulative effective dose value from each hospital using the local DRL value. The local DRL value is obtained by calculating the 2^{nd} quartile (Q_2) of all radionuclide activity data from each hospital using a formula that is already available in Microsoft Office Excel, namely in equation (3).

$$Q_2 = QUARTILE\ (A; 2) \tag{3}$$

where Q_2 is the value of the 2^{nd} quartile of the data distribution at each hospital and A is the value of all radionuclide activity at each hospital in MBq. From the second quartile value obtained from each hospital, this value is multiplied by the effective dose coefficient for Tc-99m, which is 1.9×10^{-11}Sv.Bq^{-1} [10,14].

National DRL Calculation

The calculation of the National DRL value in Indonesia uses 75% of the entire data distribution or the 3^{rd} quartile value (Q_3) of all radionuclide activity data collected in the Si-INTAN application for bone examination using the SPECT modality in nuclear medicine. The calculations used are using formulas that are already available in Microsoft Office Excel, shown in equation (4).

$$Q_3 = QUARTILE\ (A; 3) \tag{4}$$

where Q_3 is the value of the 3rd quartile of all distribution data and A is the value of radionuclide activity from all types of bone examination data with the available SPECT modality.

RESULTS AND DISCUSSION

Analysis of the Effect of Body Mass of Patients in Giving Radionuclide Activity

The effect of body mass on the provision of radionuclide activity to patients is the same as the administration of clinical drugs by doctors in the form of prescriptions given to patients based on the patient's body mass. Because radionuclides will be inserted into the patient's body, it will affect the metabolism in the body and the waiting time for radionuclides to be absorbed so that the time for the examination is precise and optimal.

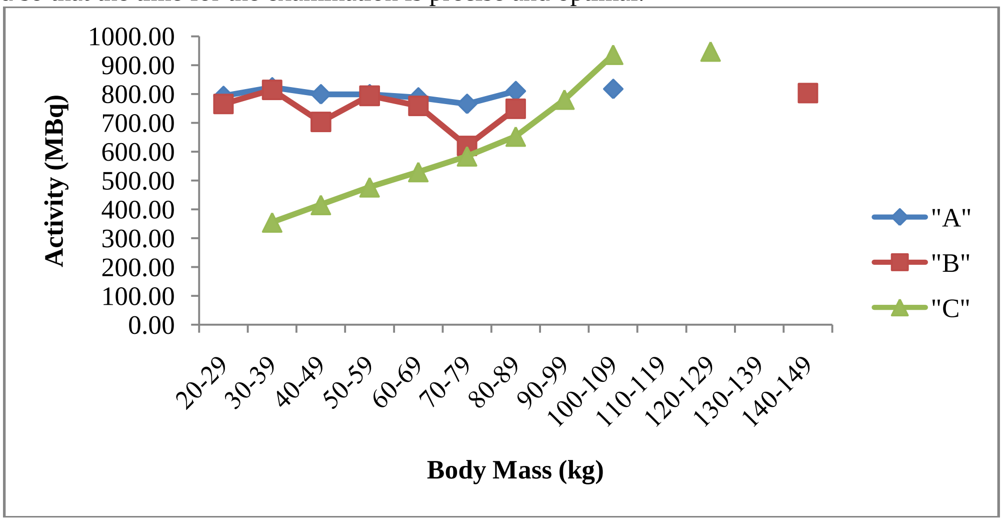

Fig. 1 Bar graph of body mass against radionuclide activity at 3 hospitals

If the hospital has administered the amount of radionuclide activity based on the patient's body mass, the resulting graph tends to increase from the smallest to the largest body mass and forms a linear graph because the amount of radionuclide activity given to the patient is proportional to the patient's body mass. It can be concluded that only hospital C has met the protocol for administering radionuclide activity based on the patient's body mass (Fig. 1).

Evidenced by the value of determination (R^2) on the linear graph of 0.96 or close to 1, in other words, the patient's body mass affects the value of the given radionuclide activity that shown in Figure 2.

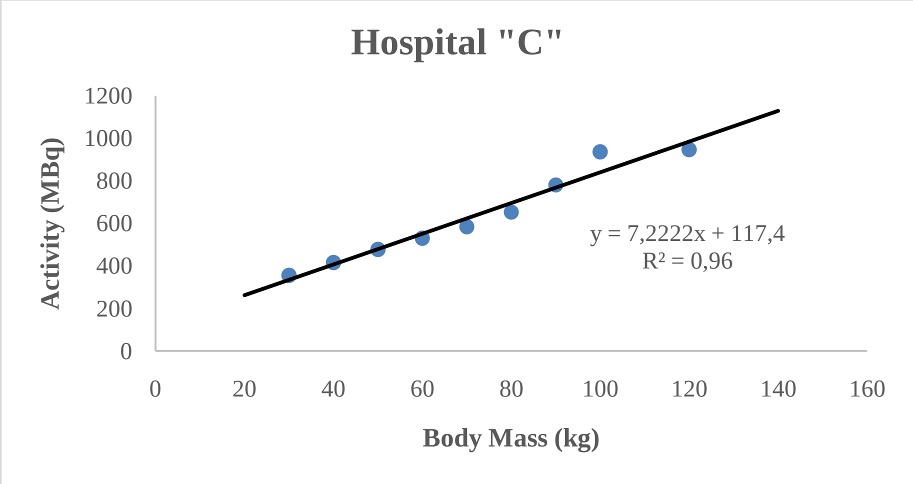

Fig. 2 Linear graph of body mass against radionuclide activity at Hospital "C"

Meanwhile, for hospitals A and B, the resulting graph tends to increase and decrease. The lowest and highest activity values of the two hospitals, respectively, lie in the body mass intervals of 70-79 kg and 30-39 kg. The factor that may be the reason for the lowest activity value being in the body mass interval 70-79 kg is the limited availability of the number of radionuclides owned by the hospital with the needs given to patients so that the hospital provides the amount of radionuclide activity divided equally close to the recommended activity size of 370-740 MBq (10-20 mCi) for each patient [19].

The factor that may affect the highest value of radionuclide activity which is in the body mass interval 30-39 kg is not the largest body mass interval at each hospital assuming concerns from diagnostic workers in the event of a repetition of imaging procedures and requests from nuclear medicine doctors to get better image results even when the amount of radionuclide activity given to the patient exceeds the recommended activity level. Therefore, thehospitals A and B that have not met the protocol for providing radionuclide activity, it is necessary to conduct field evaluations and investigations as a form of effort to implement optimization in radiation protection.

Indonesian National DRL

The value of the National DRL for Nuclear Medicine on bone examination with the SPECT modality that Indonesia has from the calculation of the 3rd quartile (Q_3) of 3 hospitals on the 2017-2018 Si-INTAN application is 791.80 MBq. The value of the National DRL in Indonesia can be compared with the value of the National DRL on several countries that already have DRL values with the same procedure, which is presented in table 1.

Table-1 National DRL scores from various countries

England 1999	**England 2019**	**Europe 2014**	**Australia 2017**	**Indonesia**
800 MBq	800 MBq	600 MBq	920 MBq	791,8 MBq

It can be seen that the National DRL in Indonesia is still lower than the DRL owned by the UK in 1999 [7] and the UK in 2019 [3] as well as the DRL in Australia in 2017 [2], but it is still higher than the DRL value in Europe in 2014 [8].

Table-2 Results of the calculation of radionuclide activity into an effective dose

Hospital	**Radionuclide Activity (MBq)**	**Effective Dosage (mSv)**
A	791,80	15,04
B	756,65	14,38
C	500,61	9,51

Hospital Local DRL and Effective Dosage

The DRL values and the effective dose of each hospital are presented in Table 2. The effective dose value is obtained from the calculation of the Q2 value of radionuclide activity from all data held by each hospital with an effective dose coefficient of Tc-99m. Table 2 it can be seen that none of the three hospitals has a value that exceeds the set National DRL value. The hospital's local DRL value can change if each hospital has followed the protocol in providing radionuclide activity to patients and this will affect the DRL value that Indonesia has to be lower than today.

CONCLUSION

The conclusion that can be drawn from this study is that in nuclear medicine, especially in bone examination using the SPECT modality, the amount of radionuclide activity is influenced by the patient's body mass, as evidenced by the value of determination (R^2) which is close to 1 on a linear graph at hospital C and only hospital. C which has met the protocol in nuclear medicine examination.

The value of the National DRL for Nuclear Medicine that is owned by Indonesia from the data of all hospitals that have been compiled from the Si-INTAN application for bone examination with the SPECT modality is 791.80 MBq. Meanwhile, the local DRL values for each hospital were 791.80 MBq, 756.65 MBq, and 500.61 MBq, respectively. The effective dose values from each hospital were 15.04 mSv, 14.38 mSv, and 9.51 mSv, respectively.

Acknowledgement

The authorswould like to thank to Nuclear Energy Regulatory Agency of Indonesia for supporting this research.

REFERENCES

[1]. ARPANSA. Safety Guide: Radiation Protection in Nuclear Medicine. *ARPANSA RPS*. 2008. No. 14.2.
[2]. ARPANSA. Nuclear Medicine Diagnostic Reference Levels (DRLs). 2017.
[3]. ARSAC. Notes for Guidance on the Clinical Administration of Radiopharmaceuticals and Use of Sealed Radioactive Sources. *Public Health England.* 2019.
[4]. BAPETEN. *Pedoman Teknis Penyusunan Tingkat Panduan Diagnostik Atau Diagnostic Reference Level (DRL) Nasional* (Rekaman Dokumen Unit Kerja Tahun 2016 No. LT/STI/KN 01/P2STPFRZR 1/077/2016). Jakarta. 2016.https://doi.org/10.1039/C5RA02987B.
[5]. BAPETEN. *Manual Penggunaan Si-INTANVer.2.0*. 2018
[6]. BATAN. Radioisotop dan RadiofarmakauntukBidangKesehatan, Pertanian, Hidrologi, Industri. Pusat DiseminasiIptekNuklir. 2007. *ISSN 0215 – 0611*.
[7]. European Commision. Radiation Protection No. 109 – Guidance on Diagnostic Reference Levels (DRLs) for Medical Exposures. 1999.
[8]. European Commission. Radiation Protection No. 180 Part 2/2 - Diagnostic Reference Levels in Thirty-six European Countries. Luxembourg. 2014.
[9]. European Commission. Radiation Protection No. 185 - European Guidelines on Diagnostic Reference Levels for Paediatric Imaging. 2018.
[10]. IAEA. Methods for Assessing Occupational Radiation Doses due to Intakes of Radionuclides. *Safety Report SeriesNo. 37*.2004.
[11]. ICRP. Publication 73 - Radiological protection and safety in medicine. *Annals of the ICRP*. 1996. 28(2): 50.
[12]. ICRP. Publication 105 - Radiation protection in medicine. 2007.
[13]. ICRP. Publication 106 - Radiation Dose to Patients from Radiopharmaceuticals. 2008.
[14]. ICRP. Publication 119 - Compendium of Dose Coefficients. 2012.
[15]. ICRP. Publication 135 - Diagnostic Reference Levels in Medical Imaging. 2017.
[16]. Jauhara, N.V. StudiAwalPenentuan*Diagnostic Reference Level* (DRL) PediatrikBerdasarkan Massa Tubuh pada Pemeriksaan*Chest Thorax Anterior-Posterior* (AP) ModalitasRadiografiUmum di Indonesia Berdasarkan Basis Data Si-INTAN. Fakutlas Sains dan Matematika. UniversitasDiponegoro, Semarang. 2019.
[17]. Kowalsky, R.J., & J.R. Perry. Radiopharmaceuticals in Nuclear Medicine Practice. Appleton and Lange; United States. 1987.
[18]. Kristiyanti, W.Z. Imran, & L. Yuniarsari. Analisis Waktu Peluruhan Terhadap Persyaratan Dosis Radioisotop Untuk Pemeriksaan Gondok. 2009.6(12): 371-375.
[19]. Saha, G.B. Fundamentals of Nuclear Pharmacy Fifth Edition. Springer; USA. 2009.