

# Determination of diagnostic reference level (DRL) on computed tomography (CT) non contrast examination

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**Abstract.** Monitoring patient doses on CT Scans in hospitals very important, it must be monitored periodically especially in DRL monitoring of CT Examination. There is still a need for socialization regarding the need for radiation monitoring of high dose radiation in CT Scan used. The DRL was related to efforts to optimize radiation protection must be monitored periodically on CTDI Vol and DLP for lowest possible dose and optimum image quality results. Determination of DRL values from 75% percentile from recording mean CTDI vol and total DLP MSCT examination of head and abdomen non-contrast. The overall results obtained from the Head MSCT examination DRL as follows: DRL on CTDI Vol from Quarters I-IV obtained 63.45 mGy, exceeding the standards IDRL requirement of 60 mGy. Meanwhile, DRL in DLP Total from Quarters I-IV was 1005.05-1096.45 mGy.cm which was lower than IDRL 1275 mGy.cm. Meanwhile, the results of the DRL on the Abdominal MSCT are as follows: Quarter I-IV is 9.35-10.31 mGy below the IDRL that was 17 mGy. Meanwhile, local DRL from Quarters I-IV obtained: 401.34 - 428.73 mGy.cm below IDRL which was 885 mGy.cm, its suitable with Decree of the Head of Bapeten Number 1211/K/V/2021.

## 1 Introduction

Technology in the field of medical imaging has developed very significantly. One of the technological developments in the medical field is the creation of *Computed Tomography* or better known as *CT scan*. *Computed Tomography* (CT) is one of the *revolutionary* in the field of medical imaging [1]. Based on data from the *International Commission for Radiological Protection*/ ICRP [2], the frequency of *CT scans* has increased rapidly from 2% of all radiological examinations in some countries to 10-15% within a decade. *Multislice CT* (MSCT) is an expanded form of *CT Scan* that has 16 or more rows of detectors that function to accommodate high-speed imaging. The use of more than one detector (*multi detector*) can increase the speed of coverage of *single slice volume* and *dual slice volume* CT Scan [1, 3]. The technical evolution of MSCT from 16 slices, 32 slices, 40 slices, and 64 slices has resulted in many clinical benefits, not only for improving diagnosis but also for use in

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radiation therapy and surgical simulation. One of the benefits of MSCT is the enhancement of 3D imaging of anatomical structures. However, the use of MSCT increases the dose received by the patient [1, 3].

This dose increase is due to scan *volume* without gaps between slices and with possible overlapping scans. In a conventional X-ray examination, the rays enter the body from one side of the body (front, back, or side). Whereas in MSCT, the X-ray tube rotates around the patient's body and X-rays penetrate the patient's body from several points, all of which are exposed to radiation. The effective dose on the thorax MSCT examination is 8 mSv and in some MSCT examinations such as in the pelvic area, the dose received by the patient is 20 mSv. The dose received by the breast on a chest MSCT examination is about 30-50 mGy, even though the breast is not the target of the imaging procedure [2]. In addition, the eye piece on the head MSCT scan, the thyroid gland on the head or *thorax*, and the gonads on the *pelvic* or *abdominal* also received high doses. Although it is possible to perform MSCT scans at lower doses than *single slice CT*, in practice patients receive higher doses because of the factors (*scanning volume*, mAs, *pitch*, slice width, etc.) [1, 3].

The radiation dose received by the patient is one of the things that must be considered when conducting examinations that use ionizing radiation, especially *CT scans*. In accordance with Government Regulation Number 33 of 2007 [4] Article 21 concerning Safety of Ionizing Radiation and Security of Radioactive Sources, one of the radiation protection requirements that must be met in the use of radiation is optimization of radiation protection and safety. Optimization efforts are carried out by making the dose received as low as possible by considering social and economic factors. Based on this, equipment manufacturers try to minimize radiation dose while maintaining informative image results (optimum image quality) [3-7].

Because of this, it is necessary to monitor the dose as dose monitoring in patients. This patient dose monitoring measure was carried out as an effort to contribute to the BAPETEN (Nuclear Energy Supervisory Agency) priority program, namely Strengthening Radiological Patient Safety Protection Guarantees. This program is carried out by monitoring patient doses through a national database on the use of ionizing radiation called the *Diagnostic Reference Level* (DRL). The preparation of DRL is carried out by each health facility that utilizes radiation, later the DRL value of each health facility will be inputted into a database application from BAPETEN. In the future, with the preparation of this DRL value, Indonesia is expected to have a patient dose profile for each type of diagnostic and interventional radiology examination as an effort to monitor and monitor patient doses (patient dose management). The cooperation and active role of the hospital or health care institution that has diagnostic and interventional radiology equipment is needed to build this dose management system by filling in the examination dose data on the BAPETEN web periodically. However, in practice in the field, not all health facilities that use *CT scans* have an active role in this program, so it needs to be socialized more intensively. So that later each hospital has a Local DRL and can contribute to the determination of the national DRL (IDRL) [8-13].

## 2 Materials and Methods

This research was carried out in stages, starting with a survey in several hospitals. From the results obtained, followed up for assistance and data collection for hospitals that have been monitoring and documenting doses on MSCT examinations. Then data was collected for non-contrast MSCT examination on imaging of the head, abdomen, and thorax organs. However, in collecting data in this study, the data obtained for the national DRL contribution (IDRL) was at least 30 patient samples [8-10]. Because the thorax does not meet the requirements or is rarely available, it does not qualify as data to be processed for DRL determination. In

determining the local DRL based on Quartile 2 (Percentile median/50% Percentile) and the contribution to the national DRL calculation is at least 30 patients, the calculation uses the determination of the third quartile (75% percentile) [8-11]. The data needed for the calculation of DRL on a CT Scan or MSCT is the CTDI vol average of one examination and the total DLP of an examination. Furthermore, dose data on patients were grouped for head and abdominal examination which were obtained retrospectively and then analyzed in 3 months (quarterly) obtained from 1 year 2020-2021 (Quarter I, II, III, and IV). Next, enter in Microsoft Excel sequentially by entering data No, Name, Gender, age, type of examination, exposure factor, CTDI vol, and DLP for radiology installations with CT Scan modalities, while for national contributions it is calculated based on quartile 3 (3<sup>rd</sup> quartile/75% percentile) [8-13].

### 3 Results

3 months to meet the requirements of 30 patients so that they can also contribute to the determination of the national DRL (IDRL) which is carried out at a hospital that has been monitoring and documenting doses on CT Scan modalities which consists of the mean of CTDI vol and total DLP are as follows:

On examination of the head and abdomen, the local Diagnostic Reference Level was obtained based on quartile II on non-contrast MSCT examination of head and abdominal organ imaging, the following data were obtained:

**Table 1.** Calculation of local Diagnostic Reference Level on Non-Contrast CT Head and Abdomen Examination based on Quartile II.

Examination	1st Quarterly	2nd Quarterly	3rd Quarterly	4th Quarterly
<b>CTDI Vol (mGy)</b>				
Head	63.45	63.45	63.45	63.01
Abdomen	8.32	8.28	8.47	7.58
<b>DRL DLP (mGy.cm)</b>				
Head	1005.05	1005.05	913.68	913.68
Abdomen	314.76	321.47	343.24	330.46

Head and abdomen obtained Diagnostic Reference Level for National contribution (IDRL) based on quartile III on non-contrast MSCT examination of head and abdomen organ imaging obtained the following data:

**Table 2.** Calculation of Diagnostic Reference Level for IDRL contribution on Non-Contrast Head and Abdominal CT Examination based on Quartile III.

Examination	1st Quarterly	2nd Quarterly	3rd Quarterly	4th Quarterly
<b>CTDI Vol (mGy)</b>				
Head	63.45	63.45	63.45	63.45
Abdomen	9.35	10.31	10.28	9.6
<b>DRL DLP (mGy.cm)</b>				
Head	1096.42	1096.42	1005.05	1005.05
Abdomen	401.4	424.68	428.73	401.34

## 4 Discussion

Regarding the regulation of dose monitoring on CT Scan, it has been regulated by Bapeten starting from 2016 related to DRL data collection (Diagnostic Reference Level) [8-10] which is a contribution from Government and Private Hospitals, Health Facilities and Clinics. The use of CT Scan for radiological imaging modalities is increasing from time to time. CT Scan has a large dose received by the patient, so it is necessary to make efforts to apply radiation protection, especially through the determination of DRL on CT Scan examinations. But until 2021, it turns out that there are still many who do not know about dose monitoring through DRL calculations. Even in 2021, the Head of Bapeten Decree Number 1211/K/V/2021 was issued regarding the determination of the value of the Indonesian diagnostic guide (Indonesian Diagnostic Reference Level) for CT Scan X-ray modalities and general radiography. DRL from CTDI vol for non-contrast head CT examination is 60 mGy and non-contrast abdomen is 17 mGy, while DRL from DLP on non-contrast CT head is 1275 mGy.cm and for non-contrast abdomen is 885 mGy.cm.

From Table 1, the local DRL value for non-contrast head CT examination is higher than IDRL because the mean CTDI vol DRL is above 60 mGy from data collection and dose monitoring from Tri Wulan I-IV. Meanwhile, the non-contrast DRL DLP from the I-IV quarters was lower than the IDRL. In contrast to the DRL value on non-contrast abdominal examination, the DRL calculation from CTDI vol and DLP from quarterly I-IV data were all lower than IDRL [8-11].

DRL is actually not for limiting or limiting doses such as not exceeding the dose limit value (NBD) [5, 8]. However, DRL data is a range of doses obtained from an examination. Measurement of this dose range must be carried out periodically from time to time, as a baseline for local DRL data as well as contributing to the determination of national DRL (IDRL). So, it can be said that this DRL is an effort to optimize the dose for CT Scan patients. Later it can be reduced gradually and evaluated comprehensively. In its implementation, for example in head examination obtained from CTDI vol exceeds IDRL, later the dose can be reduced from setting the exposure factor for both tube voltage (kV) and tube current (mAs) but along with the assessment of image quality it is still acceptable for diagnostic accuracy. In short, by setting the lowest possible dose, the image quality remains optimum [3, 8-13].

## 5 Conclusions

1. More intensive socialization is needed regarding the need for dose monitoring and dose documentation for the determination of DRL on CT Scan examinations because its use is increasingly widespread and has large doses received by patients.
2. Found that DRL from DRL calculations on non-contrast CTDI imaging of the head organs vol exceeded IDRL, it is necessary to investigate and attempt to reduce the dose by setting the re-exposure factor and evaluating the results of the image so that it remains optimal. In other words, the dose is set as low as possible and the image quality remains optimum. What can be done with periodic DRL monitoring on CT scan modality as an effort to optimize radiation protection.

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