International Journal of Allied Medical Sciences and Clinical Research (IJAMSCR)

ISSN:2347-6567

*IJAMSCR |Volume 10 | Issue 1 | Jan- Mar - 2022*
**www.ijamscr.com**

*Research article* *Medical research*

# Evaluation of Volume Computed Tomography Dose Index (CTDI-vol) and Dose Length Product (DLP) in Adult Chest CT Scan at Sanjiwani Hospital Bali

**Putu Irma Wulandari*, Ni Komang Diah Kusuma Dewi, Anak Agung Aris Diartama, Kadek Yuda Astina**

[1] *Department of Radiologic Imaging Technology, ATRO Bali, Denpasar, Bali, Indonesia*

***Corresponding author Email: Putu Irma Wulandari**

## ABSTRACT

### Background

The Indonesian government has established a national dose reference in the form of Indonesian Diagnostic Reference Levels (IDRLs) published in 2021 However, for the implementation of this IDRL to be effective, each clinical practice needs to conduct a routine evaluation of the doses received by patients and compare them with the latest *Indonesian Diagnostic Reference Levels* (IDRL).

### Aim

This study aims to evaluate the CTDI-vol and DLP values in adults during the Chest CT scan examinations at the Sanjiwani Hospital Gianyar and compare them with the Indonesian Diagnostic Reference Levels (IDRLs) 2021.

### Methods

This study is a descriptive quantitative study conducted with a survey to evaluate the CTDI-vol and DLP values on the Non-contrast Chest CT Scan examination in adult patients (> 15 years) at Hospital Gianyar. Data were collected retrospectively through digital archives in patients' folders. The data regarding patients' gender and age, examination protocols and parameters, and radiation dose in the form of CTDI-vol and DLP, were collected in this study.

### Results

A total of 93 adult non-contrast Chest CT Scan examinations were collected in this study, consisting of 58 male and 35 female patients. The 75percentile value for CTDI-vol and DLP for non-contrast Chest CT scan examination at Sanjiwani Hospital Gianyar is 5.33 mGy and 184.2 mGy*cm, respectively.

### Conclusion

The facilities' Diagnostic Reference Levels (fDRL) at Sanjiwani Hospital are still within the tolerance limit set on the Indonesian Diagnostic Reference Levels 2021. However, some examinations fell beyond the CTDI-vol and DLP references.

**Keywords:** CTDI vol, DLP, Diagnostic Reference Level, Chest CT Scan.

## INTRODUCTION

The use of CT-Scan as a powerful diagnostic imaging tool has increased significantly along with its advancement in technology and clinical use. During the pandemic, there has been a significant increase in the number of CT-Scan examinations performed in clinical practices, especially Chest CT scans. Generally, a Chest CT can diagnose pneumonia, nodule, metastases, and infiltrates [1]. In patients with covid19, Chest CT plays important role in detecting both alternative diagnoses and complications Covid 19 such as heart and lung problems [2].

Patients with moderate to severe covid-19 syndrome are referred to have Non-Contrast Chest CT [3] unless there is an indication of Pulmonary Embolism (PE) then CT pulmonary angiography is required [2]. These patients must also undergo a routine Chest CT for follow-up, so a low dose protocol is highly recommended to minimize the radiation dose received by patients [2]. Nevertheless, the radiation dose on CT scans remains a serious concern.

Radiation dose on modern CT Scanner is represented by CT dose index (CTDI) and Dose Length Product (DLP). The Computed Tomography Dose Index (CTDI) represents the amount of radiation exposure in the area adjacent to scan slices. CTDI is measured by units in mGy. The Volume Computed Tomography Dose Index (CTDI) CTDI-vol is calculated by the scanner based on the radiation output for the particular scan. CTDI is not an exact dose for patients, but it's a metric standard for the radiation dose output of CT scanners that allows users to compare the radiation output of several different CT scanners [4]. In addition to CTDI, another dose indicator in a CT scan is the Dose Length Product (DLP), given in units of mGy-cm. DLP describes the total energy absorbed and the biological effects caused by taking the scan. The DLP value was obtained from the multiplication operation between CTDI-vol and Scan length (L). Thus, the longer the scan length of the patient, the greater the DLP value received will be. Nowadays, most CT scanners automatically adjust radiation output based on the patient's size and density, therefore the CTDI-vol, and subsequently, the DLP, will vary from patient to patient. Therefore, in order to minimize dose variation in practices and to prevent unnecessary radiation doses during CT scan examinations, a standardized dose reference is needed.

The Indonesian government through Nuclear Energy Regulatory Agency, known as Badan Pengawas Tenaga Nuklir (BAPETEN), has established a national dose reference in the form of Indonesian Diagnostic Reference Levels (IDRLs) published in 2021. The IDRL was published in decree Number 1211/K/V/2021. IDRLs 2021 consists of dose references for several x-rays and CT scan examinations.

IDRL is a tool for optimizing radiation protection and safety for patients and preventing unnecessary exposures. It is called an optimization tool because it is a process to get to the optimum, i.e. towards the lowest possible patient dose that can be achieved while maintaining adequate image quality for diagnostic needs. However, for the implementation of this IDRL to be effective, all radiographers should be familiar with key points listed on this latest DRL [5][6]. Also, each clinical practice needs to conduct a routine evaluation of the doses received by patients and compare them with the latest *Indonesian Diagnostic Reference Levels* (IDRL). This study aims to evaluate the CTDI-vol and DLP values in adults during the Chest CT scan examinations at the Sanjiwani Hospital Gianyar and compare them with the Indonesian Diagnostic Reference Levels (IDRLs) 2021.

## METHODS

This study is a descriptive quantitative study conducted with a survey to evaluate the CTDI-vol and DLP values on the Chest CT Scan examination in adult patients (> 15 years) at Hospital Gianyar. Data were collected retrospectively through digital archives in patients' folders. The data regarding patients' gender and age, examination protocols and parameters, and radiation dose in the form of CTDI-vol and DLP, were collected in this study. Only non-contrast Chest CT examinations over 3 months (May-July 2021) were included in this study.

## RESULTS

A total of 93 adult non-contrast Chest CT Scan examinations were collected in this study, consisting of 58 male and 35 female patients. Male patients in this study were between the age of 27 and 91 years old, while the age of female patients ranged from 16-86 years. The examination was conducted using a US SIEMENS Somatom Definition CT Scan. The parameters used in non-contrast Chest CT Scan examination are shown in table 1 below:

**Table 1: Parameters for adult Chest CT Scan examination at Sanjiwani Hospital**

| Parameter | Range/Value |
|---|---|
| Slice thickness | 5 mm and 1 mm |
| Effective mAs | 13-137 mAs |
| kV | 100-120 kV |
| Pitch | 1.2 |

| | |
|---|---|
| Scan Time | 7 s-10 s |
| FOV | 282–370 mm |

Regarding the scan dose, there were 93 CTDI-vol and DLP values collected in this study. The data distribution for these CTDI and DLP values is displayed in table 2.

**Table 2: Distribution of CTDI-vol and DLP values from 93 non-contrast Adult Chest CT Scan examinations**

| Category | CTDI-vol (mGy) | DLP (mGy.cm) |
|---|---|---|
| Max | 13.36 | 430.1 |
| Min | 0.54 | 17.1 |
| Mean | 3.54 | 121.9 |
| Median | 3.05 | 103.2 |
| Mode | 0.95 | 31.5 |

Furthermore, from the collected data, the 3rd quartile (75th percentile) of the dose distribution of non-contrast Chest CT Scan was also calculated to obtain the value of facilities' *Diagnostic Reference Level* (fDRL), which can be seen in Figure 1 and 2 as follows.

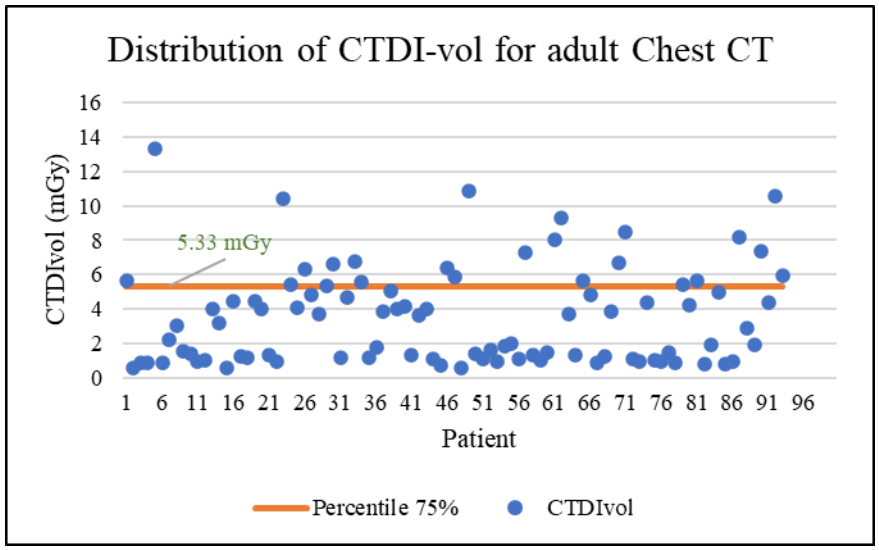


**Fig 1: Distribution of CTDI-vol for adult Chest CT Scan examination**

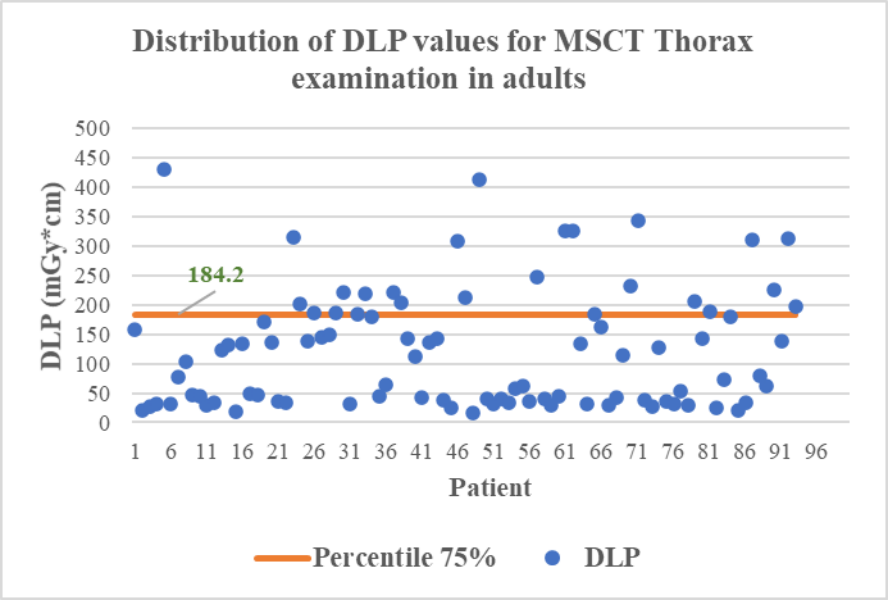


**Fig 2: Distribution of DLP values for MSCT Thorax examination in adults**

As shown in Figs 1 and 2, the 3rd quartile value for CTDI-vol and DLP for non-contrast Chest CT scan examination at Sanjiwani Hospital Gianyar is 5.33 mGy and 184.2 mGy*cm, respectively.

## DISCUSSION

The Indonesian government has set a national standard for dose reference called Indonesian Diagnostic Reference Level (IDRL), officially published in May 2021. This IDRL consists of dose references or several general x-rays and CT scan examinations. This study aims to evaluate the CTDI-vol and DLP values for Chest CT Scan Examination for adults in Sanjiwani Hospital Gianyar and to compare them to the latest IDRL.

In general, CTDI and DLP are affected by scan parameters such as kVp, mA, pitch, scan time, FOV, etc [7] [8]. According to table 1, it can be seen that the kVp used in Chest CT scans in the study hospital varied between 100-120 kVp, while the effective mAs ranged between 12 mAs and 175 mAs. Literatures [1] [9] mentioned that the standard kVp for routine Chest CT is 100-120kVp, while the mAs were ranged from 90-120 mAs and 10-20 mAs for routine chest CT and the low dose HR protocols, respectively.

The selection of kVp and mAs during CT Scan examination is highly tailored to the diagnostic needs. The scan protocol used for Chest CT during the study period were both routine and low dose Chest CTs. Low-dose Chest CT was the most common protocol used especially for patients with Covid-19. In these patients, low-dose CT examinations are possible without reducing diagnostic values and can reduce the dose by up to 90% compared to standard CT scan acquisition [2]. Furthermore, changes in the kVp value can affect CTDI-vol and DLP. Previous research found that the higher kVp used during CT Scan examination, the higher radiation dose [10].

The pitch used in this study is 1.2 for both low dose protocol and routine Chest CT scan. This is slightly lower than referred on literature [1] which is 1.3 for routine Chest protocols. Pitch is a parameter that depends on collimation and table speed. If the movement of the object or patient is faster, the pitch will increase and will decrease the duration of radiation exposure to the patient so that the radiation dose can be reduced. The radiation dose is inversely proportional to the pitch when all other factors are constant [7]. In this study, the radiation dose might be slighty higher than required as a lower pitch was used (1.2 as opposed to 1.3). However, further investigation is required to confirm this finding.

As regards scan time and FOV, these parameters are highly dependent on objects or the length of the area to be scanned. In this study, FOV varied from 282 mm to 370 mm. Meanwhile, the scan time also varied from 7 to 10 seconds.

Variation in scan parameters will result in different CTDI-vol and DLP values on chest CT scans. According to table 5, it can be seen that the highest of CTDI-vol in this study was 13.36 mGy, while the lowest CTDI-vol was 0.54 mGy. Meanwhile, the highest and the lowest DLP in this study were 430.1 mGy*cm and 17.1 mGy*cm, respectively.

The highest CTDI-vol and DLP values in this study exceeded the national standard referred by IDRL 2021 (11 mGy for CTDI-vol and 430 mGy*cm for DLP). According to Bapaten-- [11], if a patient's dose exceeds the DRL, it is necessary to record and conduct a review to find possible causes and options for appropriate corrective action, unless the dose cannot be avoided and must be avoided be medically justified. Corrective

actions must be taken so that the dose from time to time can be reduced which results in the DRL value being more dynamic towards the lowest possible direction.

In this case, when the study data was evaluated, it is found that the *effective* mAs used in the particular scan was 175 mAs, which was significantly higher than those used for other patients, ranging from 12 to 74 mAs, while other parameters remained the same. The selection of tube current (mAs) on CT Scan acquisition determines the number of X-ray quanta to the detectors. A higher tube current will result in a higher radiation dose [10].

As regards the local or facilities Diagnostic Reference Level (fDRL), Figures 1 and 2 show that the 75 percentiles of CTDI-vol and DLP in this study were 5.33 mGy and 184.2 mGy*cm, respectively. These values are lower than those stated in the latest Indonesian Diagnostic Reference Levels (IDRLs) which are 11 mGy for CTDI-vol and 430 mGy*cm for DLP. In this case, the author compared the 75 percentile of CTDI-vol and DLP in the study hospital with IDRL as the calculation method of IDRL was based on the 75 percentile of dose distribution conducted on a national survey [11].

Radiation protection for patients is a continuous thing, not only stopping after a DRL value is obtained. Establishing a DRL is only the first step in optimizing patient protection. Medical practitioners must always strive to optimize the DRL and improve patient care so that diagnostic goals are achieved [6]. The purpose of this diagnostic is to obtain an optimal radiographic image so that the diagnostic information needed by the doctor is obtained by always seeking the lowest possible radiation dose for patients that can be achieved by following the As Low As Reasonably Achievable (ALARA) principle [5] [8][11].

Therefore, the level of diagnostic guidance for medical exposure or DRL is highly recommended to be used as a guide for medical practitioners in optimizing protection for each type of Diagnostic and Interventional Radiology examination and used to prevent unnecessary radiation exposure to patients [11].

## CONCLUSION

The 75th percentile of CTDI and DLP during the Chest CT Scan for adults from May to July 2021 at the Sanjiwani Hospital was 5.33 mGy and 184.2 mGy*cm, respectively**.** These values are still within the tolerance limit set on the Indonesian Diagnostic Reference Levels 2021. However, some examinations fell beyond the CTDI-vol and DLP references.

## SUGGESTION

Given the importance of evaluating the radiation dose on a CT Scan, it is necessary to carry out a routine evaluation of the dose received by the patient and compare it with the latest standards to prevent unnecessary radiation exposure to patients, so that the lowest possible patient radiation dose can be achieved without compromising the quality of the radiographic image.

## REFERENCES

1. Wijokongko S, Ardiyanto J, Fatimah AP Utami. Rustanto, and Setiawan. Protokol CT Scan dan MRI. Magelang: Inti Medika Pustaka, 2017.
2. Kwee TC, Kwee RM. Chest ct in covid-19: what the radiologist needs to know. RadioGraphics. November 2020;40(7):1848-65. doi: 10.1148/rg.2020200159, PMID 33095680.
3. Rodrigues JCL, Hare SS, Edey A, Devaraj A, Jacob J, Johnstone A, McStay R, Nair A, Robinson G. An update on COVID-19 for the radiologist - A British society of Thoracic Imaging statement. Clin Radiol. May 01, 2020;75(5):323-5. doi: 10.1016/j.crad.2020.03.003, PMID 32216962.
4. Sari DA, Setiawati E, Arifin Z, Fisika D, Sains F, Diponegoro U. Analisis Nilai computed tomography dose index (Ctdi) phantom kepala menggunakan Ct Dose profiler dengan variasi pitch. Berk Fis. 2020;23(2):42-8.
5. Seeram E, Brennan PC. Radiation protection in diagnostic X-ray imaging, no [book, whole]. Burlington, MA: Jones and Bartlett Publishers Learning; 2017.
6. Wulandari PI. Diagnostic reference levels: a review. J Med Sci Clin Res. 2018;6(12):508-14. doi: 10.18535/jmscr/v6i12.80.
7. Latifah R, JNJ, Nurdin DZI, Budi, "Journal of Vocational Health Studies ( LDL ) Pediatric Patients On Ct Head Examination Based On Size-Specific Dose Estimates ( SSDE ) VALUES vol. 02, pp. 127-33, 2019. doi: 10.20473/jvhs.V2I3.2019.127-133.
8. Irsal M, Winarno G. Pengaruh Parameter Milliampere-Second (mAs) terhadap Kualitas Citra Dan Dosis Radiasi Pada Pemeriksaan CT scan Kepala Pediatrik. J Fis Flux J Ilm Fis FMIPA Univ Lambung Mangkurat. 2020;17(1):1. doi: 10.20527/flux.v17i1.7085.
9. Bruening R, Flohr T. Protocols for multislice CT: 4- and 16-row applications. Springer-Verlag; 2003.
10. Wibowo AS, Wibowo GM, Prabowo A. Analisis Perubahan kV dan mAs terhadap Kualitas Gambar dan Dosis Radiasi pada Pemeriksaan multislice Computed Tomography Abdomen dalam Kasus Tumor Abdomen di Instalasi Radiologi RSUD dr. Saiful Anwar Malang. J Imejing Diagn. 2016;2(1):129-33. doi: 10.31983/jimed.v2i1.3170.

11. Bapeten. Pedoman teknis penyusunan tingkat panduan Diagnostik ATAU diagnostic reference level (DRL) Nasional; 2019.

**How to cite this article**: Putu Irma Wulandari, Ni Komang Diah Kusuma Dewi, Anak Agung Aris Diartama, Kadek Yuda Astina. Evaluation of Volume Computed Tomography Dose Index (CTDI-vol) and Dose Length Product (DLP) in Adult Chest CT Scan at Sanjiwani Hospital Bali Int J of Allied Med Sci and Clin Res 2022; 10(1): 114-119.

**Source of Support:** Nil. **Conflict of Interest:** None declared.