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Determination of Diagnostic Reference Level (DRL) in Non-Contrast and Contrast Thorax CT Scan Examinations at Bali Mandara Regional Hospital

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Abstract: A study has been conducted to determine the Diagnostic Reference Level (DRL) in non-contrast and contrast chest CT scan examinations at Bali Mandara Hospital. The study was conducted at the Radiology Installation of Bali Mandara Hospital using dose reports from non-contrast and contrast chest CT Scan examinations with data obtained including age, gender, kV, mAs, slice thick, time rotation, Pitch, as patient information and protocols used in the examination and dose information in the form of CTDIvol and DLP. This study aims to determine the local DRL value against the national DRL value. The method used to determine the DRL value in this study is by collecting data in the form of recording and documenting the dose report of CT Scan examination patients, with the data for each examination being as many as 30. From the recorded data, the CTDIvol and DLP values are used to find the DRL value by sorting it from the smallest to the largest value and then calculating the 3rd quartile as a determinant of the local DRL. The interpolation method is also used to consider the position of the 3rd quartile so that it is at a decimal value. From the research results, the CTDIvol value for non-contrast thorax examination was 6.43 mGy, and the DLP value was 293.08 mGy.cm. Meanwhile, in contrast to the thorax examination, the CTDIvol value was 6.14 mGy, and the DLP value was 852.57 mGy.cm. Furthermore, a statistical analysis was carried out in the form of a one-way t-test using SPSS software, which was used to compare the DRL values of both CTDIvol and DLP non-contrast and contrast thorax examinations with the standard values set by BAPETEN 2021 as a reference used in Indonesia. Based on the results of the analysis with a one-way t-test, it can be seen that the DRL values for non-contrast thorax examinations (DRL CTDIvol and DLP) and contrast examinations (DRL CTDIvol) do not exceed the standards set by BAPETEN. However, in the contrast thorax CT Scan examination, the DRL DLP value exceeded the standard value set by BAPETEN, so dose optimization was needed by re-evaluating the protocol implemented at Bali Mandara Hospital.

Keywords: CT scan; DRL; Thorax contras; Thorax non contras

Introduction

Computed Tomography (CT) Scan is an advanced diagnostic tool that utilizes X-rays to detect diseases and abnormalities within the human body. In producing radiographic images, CT Scan employs a tomographic method that displays cross-sections of the body (Kathon et al., 2022; Silvia et al., 2013). Over time, the use of CT

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scans has increased to meet the demands of disease diagnosis. Scanning with CT scans is commonly used due to its ability to produce clearer and more detailed images, including three-dimensional representations that encompass axial, coronal, and sagittal sections, making it highly effective in diagnosing abnormalities in the human body (Bushberg, 2012; Puspita et al., 2018).

However, with the increasing prevalence of CT scans, examinations using CT scan machines have begun to receive serious attention, particularly regarding the doses received by patients. Radiological imaging with CT scans delivers a greater radiation dose compared to other modalities (Pratama et al., 2020). Even the smallest dose of radiation received by patients has the potential to cause effects (Chuninghum, 1983). Higher doses received by patients can also potentially lead to cellular damage in body tissues and genetic damage in the form of mutations in reproductive cells (Chau et al., 2022; Mardliyyah et al., 2020; Yogantara et al., 2021). Furthermore, excessive radiation doses can increase the risk of deterministic effects, which occur when an individual is exposed to high doses exceeding a threshold, as well as stochastic effects, which are random in nature and have no threshold dose. For example, damage to the network occurs when the radiation dose exceeds a certain threshold, such as skin erythema (redness of the skin), hair loss, cataracts, organ damage, as well as long-term effects such as an increased risk of cancer and genetic mutations that can be inherited by the descendants of individuals exposed to radiation (Chuninghum, 1983; Susanto, 2018).

One of the most frequently conducted examinations using a CT scan is the thoracic examination. The thoracic CT scan is performed to detect and identify pathologies and abnormalities such as lung lesions, and to provide a detailed depiction of conditions such as lung diseases and thoracic injuries, thereby enhancing diagnostic accuracy and supporting effective treatment planning (Hussain et al., 2022; Lestari et al., 2022). The thoracic examination is divided into two parts: examinations conducted without non-contrast media (non-contrast thorax) and examinations using contrast media (contrast thorax). The two examinations differ in that the examination without contrast media is conducted without introducing contrast media into the patient's body, while the thoracic CT scan with contrast is a CT scan procedure performed on the chest area (thorax) that utilizes contrast media or substances administered through intravenous injection, meaning that the contrast fluid is injected through the venous blood vessels (Seeram et al., 2013). Contrast media are substances or media introduced into the patient's body to assist in radiological examinations, making the examined organs appear more radiopaque or more radiolucent, thereby enhancing the visualization of these organs so that the resulting images appear clearer and sharper. In other words, the contrast media function as a dye to better discern the differences between normal and abnormal tissues. By using contrast media, anatomical details and small lesions can be more clearly observed (Dewi et al., 2025; Pomara et al., 2015; Sudirman et al., 2024).

From the two examinations, another difference lies in the number of tests conducted, where in the non-contrast thorax examination, the test is only performed once, while in the contrast thorax examination, it is performed between three to five times. Thus, it can be stated that the dose received during the contrast thorax examination is greater, making it very important to pay attention to avoid undesirable side effects in patients (Ginting et al., 2023). The Nuclear Energy Supervisory Agency (BAPETEN) strives to optimize radiation doses by implementing Diagnostic Reference Levels (DRL). The concept of Diagnostic Reference Levels (DRL) was initially introduced by the International Commission on Radiological Protection (ICRP) in 1996 as part of radiation protection and safety efforts for patients (Latifah et al., 2019; Paulo et al., 2020). Diagnostic Reference Level (DRL) is a dose magnitude established as a reference or benchmark to identify and monitor the radiation dose received that may exceed the safe limits for specific examination types (Irsal et al., 2023). The Diagnostic Reference Level (DRL) plays a crucial role as a reference dose or guideline accepted during radiographic and therapeutic examinations, thereby preventing high radiation doses to patients due to inaccuracies in equipment and radiographic procedures (Osman et al., 2017; Susanto, 2018).

Therefore, the government is obligated to establish the dose levels as standards and references for identifying and monitoring the intake of radiation doses that may exceed safe limits during various types of radiological and interventional examinations, including in nuclear medicine. In the context of CT Scan examinations, radiation dose can be measured using two indicators: Computed Tomography Dose Index Volume (CTDIvol) and Dose Length Product (DLP) (Anam et al., 2021; Imai et al., 2015). CTDIvol indicates the output dose of the CT Scan, while DLP represents the total dose received by the patient during the examination (Maldjian et al., 2013). The CTDIvol and DLP values are displayed directly on the CT Scan workstation before and after the radiation is administered. Before radiation, an estimated dose value that the patient will receive is shown based on the parameter settings to be used during the examination; if the obtained dose is excessive, adjustments can be made to the parameters used. Meanwhile, after radiation, the displayed CTDIvol and DLP values represent the actual values received by the patient during the duration of radiation (Coakley et al., 2011; Diartama et al., 2024). By displaying the values of CTDIvol and DLP, it allows healthcare professionals to monitor the radiation dose administered to patients, ensuring that the dose given is accurate and in accordance with existing standards. For example, for thoracic CT scan examinations, the established DRL values are 11 mGy for CTDIvol and 430 mGy.cm for DLP in non-contrast examinations, and 16 mGy for CTDIvol and 810 mGy.cm for DLP in contrast examinations. The DRL values for non-contrast and contrast thoracic CT scans represent standard values; if the dose received exceeds the established standards, an evaluation in the form of dosage optimization is required, which is a principle of dose administration. With the existence of DRL, healthcare professionals can more easily identify and avoid situations where patients receive excessively high radiation doses, thereby enhancing patient safety and maintaining the quality of radiological examinations (BAPETEN, 2020).

However, it should be noted that radiographic examination procedures may vary in each hospital, influenced by the clinical practices applied, the modalities used, and the procedures of each type of examination, resulting in differing procedures. Therefore, this research focuses solely on the determination of Diagnostic Reference Levels (DRL) for contrast and non-contrast CT Scan Thorax at Bali Mandara Hospital, using guidelines set forth by the Nuclear Energy Supervisory Agency (BAPETEN) which regulates the determination of DRL utilized in Indonesia.

Method

This study was conducted at the Radiology Installation of Bali Mandara Regional Hospital. The tools and materials used were a Siemens brand CT Scan machine type 128 Slice Somatom MCT-172 with serial number 66935671, a control computer, and patient medical record data. The data used in this study were secondary data in the form of dose reports of non-contrast and contrast thorax CT Scan patient examination results at Bali Mandara Hospital. The data taken were the X-ray tube voltage value (kV), X-ray tube current time (mAs), rotation time, pitch, CTDIvol and DLP, non-contrast and contrast, number of phases with age categories ≥ 15 years, and patient data totaling 30 patients. The variables used in this study were independent variables in the form of X-ray tube voltage values (kV), X-ray tube current (mAs), dependent variables in the form of DRL values on non-contrast and contrast thorax CT scans, and control variables, namely pitch and time rotation. The research procedures included data preparation on DICOM and data analysis, which was carried out using software. Briefly, the research flow is shown in Figure 1.

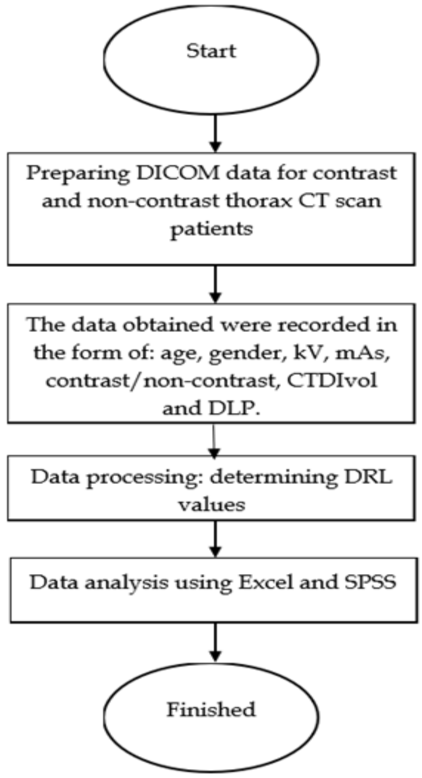

Figure 1. Research flow diagram

Data processing in this study was carried out by finding the DRL CTDIvol and DLP values in both types of examinations, both contrast and non-contrast examinations, using quartile three based on BAPETEN regulations regarding DRL determination. DRL can be determined using the third quartile value (75th percentile). The third quartile (75th percentile) is the middle value between the median and the highest value of the data group, so this value is used because it is a marker that the data in that quartile is 75% of the lowest data group so that it covers the overall value of the distribution of existing data, thus providing clearer information about the existing data, namely dose (BAPETEN, 2021). It is very important to consider this when determining the DRL value. Mathematically, the third quartile is formulated in Equation 1 (Duandini et al., 2021).

$$n_{q3} = \frac{3(n+1)}{4} \quad (1)$$

Description:
n_{q3} = third quartile position
n = number of data

After obtaining the DRL value, data analysis was carried out. The analysis was carried out to compare the

DRL value in examining non-contrast and contrast CT scan patients with the BAPETEN DRL value used as a standard. The determination of the DRL value by BAPETEN for non-contrast CT scan thorax CTDIvol was 11 mGy and DLP was 430 mGy.cm, while for contrast CT scan thorax DRL, CTDIvol was set at 16 mGy and DRL DLP was 810 mGy.cm (BAPETEN, 2021), indicating that this value is the standard value set by BAPETEN. The DRL value is the recommended radiation dose for CT scan thorax examinations, both non-contrast and contrast. In other words, this value is a limit set to ensure that radiation exposure to patients remains safe and effective during the examination. The data analysis carried out in this study was in the form of statistical testing. The statistical test used to compare the DRL value obtained with the BAPETEN standard was the one-way t-test using SPSS software. The one-way t-test was used in this study because it was in accordance with the objectives of this study, and the data criteria contained in this study were in accordance with the criteria for the one-way t-test, namely the number of data ≤ 30. After the test, a measurement graph was made using Excel software to visualize the results obtained. However, it should be noted that before the t-test is carried out, a normality test is first carried out to see the data distribution, namely whether or not the data to be tested is normal. The normality test is important because it is required to conduct a t-test; the data must be normally distributed. In the study, the Shapiro-Wilk normality test was used because the amount of data was following the criteria for the normality test. The normality test shows that if sig > 0.05, it is normally distributed and can be continued with the t-test (Strong et al., 2018). From the statistical tests, it is expected to meet a 95% confidence level with a significance of 0.05. The statistical hypotheses put forward are as follows:

H_0: The DRL value obtained does not exceed the limit set by BAPETEN.

H_1: The DRL value obtained exceeds the limit set by BAPETEN.

From the results of the statistical tests, the t_{table} value and the t_{count} value obtained will be seen and compared. If the calculated $t_{count} < t_{table}$, hypothesis H_0 is accepted and H_1 is rejected; conversely, if the calculated $t_{count} > t_{table}$, H_0 is rejected, and H1 is accepted (Strong et al., 2018).

Result and Discussion

The research was done using CT Scan on non-contrast and contrast thorax examinations for patients aged ≥ 15 years. Then, from the data can be determined the local DRL value for CT Scan non-contrast and contrast thorax examination, such as one example of calculating the third quartile position of CTDIvol non-contrast thorax examination using Equation 1. CTDIvol data is sorted first from the smallest to the largest. Then the third quartile position of CTDIvol non-contrast thorax examination is determined with n being the number of data or the number of non-contrast thorax examination patients, large n = 40.

$$n_{q3} = \frac{3(n+1)}{4} = \frac{3(30+1)}{4} = \frac{3(31)}{4} = \frac{91}{4} = 22.75$$

Since the n_{q3} result is a decimal, the third quartile position is determined using the interpolation method, as shown in the equation below. An example of calculating the third quartile value in a male patient is as follows.

Table 1. Interpolation of CTDIvol Non-Contrast Thorax Examination

3rd quartile position(q_3)	$CTDI_{vol}$
22 (x_1)	6.38 (y_1)
22.75 (x)	Y (y)
23 (x_2)	6.54 (y_2)

Description:
Y = third quartile value
x = third quartile position
x_1= Position before third quartile
x_2= Position after third quartile
y_1 = Value before third quartile
y_2 = Value after third quartile

$$\begin{aligned} Y &= (y_1) + (x - x_1) \times \left(\frac{y_2 - y_1}{x_2 - x_1}\right) \\ &= 6.38 + (22.75 - 22) \times \left(\frac{6.45 - 6.38}{23 - 22}\right) \\ &= 6.38 + 0.75 \times \left(\frac{0.07}{1}\right) \\ &= 6.38 + 0.75 \times 0.07 \\ &= 6.38 + 0.052 \\ &= 6.43 \text{ mGy} \end{aligned}$$

The above method is carried out in every third quartile position with a decimal value. For CTDIvol non-contrast thorax patients in the third quartile, the value is 6.43 mGy, which is called the DRL CTDIvol value. The same method is also used to obtain the DRL DLP value. The results of the calculation of DRL CTDIvol and DRL DLP in this study are called local DRL, which is compared with the national DRL in non-contrast and contrast thorax examinations are shown in Table 2 and Table 3 below show the results.

Table 2. Comparison of Local DRL CT Scan Non-Contrast Thorax Examination with National DRL

	CTDIvol (mGy)	DLP (mGy.cm)
Research (RSUD Bali Mandara)	6.43	324.33
National (BAPETEN)	11	430

Table 3. Comparison of Local DRL CT Scan Contrast Thorax Examination with National DRL

	CTDIvol (mGy)	DLP (mGy.cm)
Research (RSUD Bali Mandara)	6.14	852.57
National (BAPETEN)	16	810

After obtaining the DRL CTDIvol and DLP values, a comparison graph was also made between the local DRL and the national DRL on non-contrast and contrast thorax CT scan examinations, as in Figure 2 and Figure 3.

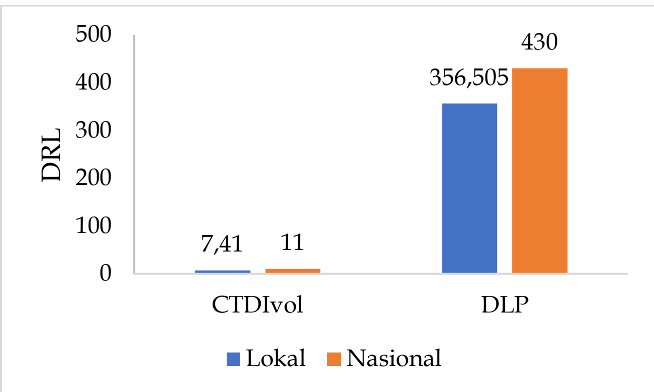

Figure 2. Comparison graph between local DRL and national DRL on non-contrast thorax CT scan examination

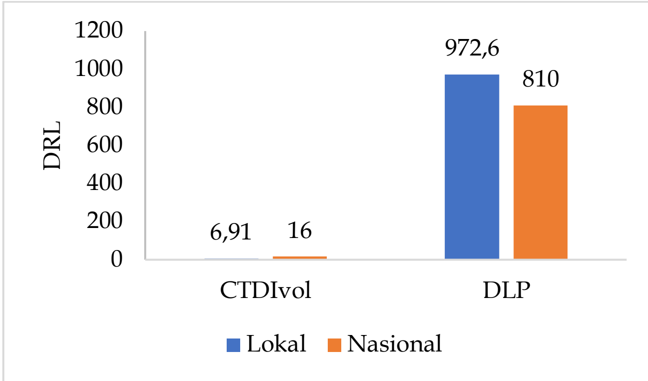

Figure 3. Comparison graph between local DRL and national DRL on contrast thorax CT scan examination

Next, a statistical test was conducted, namely a one-way t-test. Before using the t-test, a normality test was conducted using SPSS software. The following are the results of the normality test on a non-contrast thorax CT Scan examination, as shown in table 4 and table 5.

From table 4 and table 5, the results of the normality test showed a significance value of 0.192 for CTDIvol and 0.054 for DLP. By the provisions, if the sig value > 0.05, then the data is normally distributed so that the calculation can be continued with a one-way t-test (One Sample t-test) using SPSS software to determine whether the DRL value obtained exceeds the established standard or not. The results of the t-test on the CTDIvol and DLP values in non-contrast thorax examinations are shown in table 6 and table 7.

Table 4. Results of the Normality Test of CTDIvol Values for Non-contrast Thorax CT Scan Examinations

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	sig	Statistic	df	sig
CTDlvol_Non_contrast	.121	30	.200	.932	30	.056

a.Liliefors significance correction

Table 5. Results of the Normality Test of DLP Values for Contrast Thorax CT Scan Examinations

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	sig	Statistic	df	sig
DLP_Non_contrast	.107	30	.200	.956	30	.248

a.Liliefors significance correction

Table 6. Results of the t-Test of CTDIvol Values for Non-contrast Thorax Examination

	Test Value = 11					
					95% Confidence interval of the difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
CTDlvol_Non_contrast	-25.468	29	.000	-5.41800	-5.8531	-4.9829

Table 7. Results of the t-Test of DLP Values for Non-contrast Thorax Examination

	Test Value = 430					
					95% Confidence interval of the difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
DLP_Non_contrast	-13.821	29	.000	-158.81167	-182.3134	-135.3099

The overall t-test results for both t count and t table of CTDIvol and DLP values are shown in Tables 8 and 9.

Table 8. Results of the CTDIvol and DLP t-Tests for Non-contrast Thorax Examinations

CTDIvol			DLP
t_{count}	t_{table}	t_{count}	t_{table}
-25.47	1.67	-13.82	1.67

P value = 5% = 0.05

Table 9. Results of the CTDIvol and DLP t-Tests for Contrast Thorax Examinations

CTDIvol			DLP
t_{count}	t_{table}	t_{count}	t_{table}
-55.33	1.67	-2.15	1.67

P value = 5% = 0.05

CT Scan machines have a relatively higher radiation dose compared to other radiology devices. The CT Scan dose currently used is CTDIvol and DLP. The radiation dose in a CT Scan examination can be determined by identifying the CTDIvol and DLP value indicators that can be found in the DICOM data of each patient. CTDIvol is the average dose of the entire scan series volume and DLP is the total dose during the examination.

This research aims to determine the local Diagnostic Reference Level (DRL) for non-contrast and contrast-enhanced chest CT scans at Bali Mandara Hospital and to assess whether the DRL values at Bali Mandara Hospital exceed the National DRL (BAPETEN). The study collected data from 30 non-contrast and 30 contrast patients. The collected data include tube voltage (kV), exposure time (mAs), slice thickness, rotation time, CTDIvol, and DLP. The CTDIvol and DLP values are used to establish the local DRL, followed by a comparison with the national DRL values. The study resulted in local DRL values for non-contrast and contrast chest CT scans in adult patients aged ≥ 15 years, as presented in Table 1 and Table 2. It is observed that the DRL values of CTDIvol and DLP at Bali Mandara Hospital for non-contrast thoracic CT scan examinations are 6.43 mGy and 293.08 mGy.cm, respectively. Meanwhile, the CTDIvol and DLP values at Bali Mandara Hospital for contrast thoracic CT scan examinations are 6.14 mGy and 852.57 mGy.cm. It can be seen that the DRL values at Bali Mandara Hospital for non-contrast thoracic CT scan examinations are lower than the national DRL set by BAPETEN, where the national DRL limits for non-contrast thoracic CT scan examinations are a CTDIvol of 11 mGy and a DLP of 430 mGy.cm. Meanwhile, in the contrast CT scan examination of the thorax, the CTDIvol value was 16 mGy, and the DLP was 810 mGy.cm; however, the DRL DLP result for the contrast thorax examination exceeded the established quality standard. This may occur due to several factors, including the exposure factors used in the examination, such as kV and mAs parameters (Khusniatul et al., 2014; Missinychrista et al., 2023). These parameters significantly influence the dose received by the patient during the examination because kV and mAs are directly proportional to the quantity and quality of the radiation. Therefore, the higher the kV and mAs used, the greater the dose administered (Sari et al., 2018; Sumarsono et al., 2020).

According to the results obtained by (Dinayawati et al. (2024), it indicates that the causes of dose values exceeding the diagnostic guideline limits are due to exposure factors that surpass the existing standards, specifically for kV standards of 120 kVp and mA of 80-100 mA, thus emphasizing the importance of adhering to radiation dose guidelines. Additionally, the high dose during contrast examinations is attributed to the number of scans performed. The use of contrast agents requires several additional phases, with the selection based on the targeted area being observed, leading to a total of up to five scans (Abimanyu et al., 2017). Therefore, the dose received during contrast examinations is greater than that received during non-contrast examinations, which only involves one scan.

Another factor that also influences the dosage is the characteristics and size of the patient's body. Patients with a larger body weight tend to receive a higher dosage compared to those with a smaller body weight. This is again related to the adjustment of exposure factors, namely kV and mAs. Furthermore, the size of the patient's body is directly proportional to the length of the scan; therefore, as the length of the scan increases, the dosage received also increases, especially in terms of DLP, because DLP is significantly affected by the length of the scan (Noveranty et al., 2024; Raharja et al., 2023; Wangko et al., 2013). Regarding this matter, upon closer examination, it can also be influenced by the inspection protocols, namely the determination of the scanning limits applied clinically. In thoracic examinations, a greater scanning length can be achieved (from the neck to beneath the diaphragm), which does not conform to the thoracic examination protocol that sets the limits from beneath the neck to the diaphragm, resulting in a higher dose received by the patient. The findings obtained are from a study conducted by Ginting et al. (2023), which also indicates that the DRL results exceed the standards during contrast-enhanced CT scans, but pertain to different organs, namely the abdomen.

Based on the statistical analysis, the data analysis in this study showed that the local DRL value did not exceed the standard set by BAPETEN. Based on the statistical analysis of the data in this study shows that the local DRL value did not exceed the standard set by BAPETEN. This is proven by using a one-way t-test with SPSS software, which shows that the CTDIvol and DLP values in both non-contrast and contrast thorax examinations do not exceed the standards set by BAPETEN. It can be seen in Table 4 that the results of the CTDIvol t-test in patients with non-contrast thorax examinations obtained a t_{count} value < t_{table} where the t_{count} value is -25.47 and the t_{table} is 1.67. Likewise, the results of the DLP t-test obtained a t_{count} value < t_{table} where the t_{count} value is -13.82 and t_{table} is 1.67.

Meanwhile, in Table 5, the results of the CTDIvol t-test on patients with contrast thorax examination obtained a t_{value} < t_{table} where the t-value was -55.33 and the t-table was 1.67. Likewise, the results of the DLP t-test obtained a t_{value} < t_{table} where the t_{value} was -2.15, and the t_{table} was 1.67 with a p-value of 0.05. Therefore, H0 is accepted, and H1 is rejected, which means that the DRL value for both non-contrast and contrast thorax examinations at Bali Mandara Hospital does not exceed the value limit set by BAPETEN. From the results obtained, it is known that there is a difference between the quantitative results and the statistical results, especially in the contrast thorax DRL (DLP). The results obtained quantitatively show that the DRL (DLP) exceeds the BAPETEN Standard DRL, while the statistical results show that the DRL (DLP) does not exceed the BAPETEN standard. From the results obtained with the confidence level used, namely 95% (α = 5%), there is a possibility of a type II error, namely failing to reject H0. But quantitatively, it exceeds the existing standard. The existence of a type II error can be influenced by several things, one of which is a small effect size where from the results, it can be seen that the difference in the DRL (DLP) values obtained does not have a large difference from the standard DRL (DLP) value, meaning that the value that exceeds the standard is not so far that the statistical test can fail to detect the difference.

It should be noted that DRL is not a determinant of the radiation dose limit but rather a comparative material so that the radiation exposure received by the patient remains optimal so that from the results of the DRL value obtained, the value can be used to optimize excess radiation exposure from the CT Scan machine for non-contrast and contrast thorax examinations, especially for contrast thorax examinations whose values exceed the existing reference. So that it is necessary to re-evaluate and follow up on the protocol applied to the examination. The evaluation can be in the form of changes to the examination protocol on the exposure factor so that patients get the lowest dose but do not reduce the quality of the resulting image. The protocol applied is very important to note because it greatly affects the results of the examination carried out both on the dose received by the patient and the resulting image. Based on BAPETEN Regulation Number 4 of 2020 concerning radiation safety in using X-ray devices in radiology and intervention, the DRL value is expected to be monitored periodically (BAPETEN, 2020). Therefore, this study needs to be continued to see how the optimization of the protocol is carried out on the dose received by the patient and the image results obtained after optimization is carried out.

Conclusion

Based on the research that has been conducted, it can be concluded that the DRL value of non-contrast and contrast thorax CT Scan examinations at Bali Mandara Hospital, namely the DRL CTDIvol and DLP values on non-contrast thorax CT Scan examinations of 7.27 mGy and 347.655 mGy.cm. The CTDIvol and DLP values on contrast thorax CT Scan examinations were 6.91 mGy and 935.69 mGy.cm. The results did not exceed the BAPETEN DRL standard value on the DRL (CTDIvol and DLP) on non-contrast thorax CT Scan examinations and DRL (CTDIvol) on contrast thorax CT Scan examinations. However, for the DRL (DLP) of contrast thorax examinations, the results exceeded the standard value of BAPETEN. This can be an evaluation for hospitals to optimize the dose by re-evaluating the examination protocol applied in the hospital so that by implementing the appropriate protocol, patients can receive great benefits without having an impact or effect after undergoing the examination.

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Author Contributions

Conceptualization, N.L.E.P. and G.N.S.; methodology, formal analysis, resources, data curation, writing—original draft preparation, visualization, N.L.E.P.; validation, investigation, G.N.S. and N.L.P.T.; writing—review and editing, N.L.E.P., G.N.S., N.L.P.T., N.N.R., H.S., and W.T.B. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare that there is no conflict of interest regarding the publication of this article.

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