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ORIGINAL ARTICLE

Analysis of the Effective Dose of Non-Contrast Head CT-Scan Examination Base on Gender Using the Radiation Dose Calculator at Hermina Bitung Hospital Analisis Dosis

Efektif Pemeriksaan CT-Scan Kepala Non-Kontras Berdasarkan Gender Dengan Menggunakan Kalkulator Dosis Radiasi Di RS Hermina Bitung

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ABSTRACT

Background
The need for CT Scan radiology examinations, which offer more detailed image results than X-rays, continues to increase. Head CT scans are the most frequently performed examinations, reaching 60%.
Objective
This study aims to evaluate the effective dose distribution of radiation to the tissues involved in head CT-Scan examinations at RS Hermina Bitung and assess its compliance with the regulations set by the Indonesia Diagnostic Reference Level (I-DRL).
Methods
This study involved 100 patients, consisting of 50 men and 50 women. Data in the form of Dose Length Product (DLP) values were collected from each patient and converted to effective dose using a radiation dose calculator.
Results
The results showed that 6 out of 100 samples exceeded the dose limit set by the Nuclear Energy Regulatory Agency (BAPETEN). Factors that affect the effective dose include exposure, body weight, object thickness, scan length, age, tissue weight, tissue sensitivity, FOV, and pitch. Nonetheless, the overall average effective dose of the patients was still within the I-DRL.
Conclusions
Factor such as gender can affect the effective dose received by patients. The 75 percentile value of the effective dose of non-contrast head CT-Scan examination at Hermina Bitung Hospital is in accordance with the provisions of the I-DRL. The radiation dose calculator used can be applied in Indonesia, but still requires increased information literacy regarding its use.

Keywords: CT-Scan; DLP; Dose Calculator; Radiation Dose.

ABSTRAK

Latar Belakang

Pemeriksaan radiologi CT Scan yang memiliki keunggulan hasil gambar yang lebih detail dibandingkan Sinar X terus meningkat kebutuhannya. CT Scan kepala adalah pemeriksaan yang paling sering dilakukan yaitu mencapai 60%.

Tujuan

Penelitian ini bertujuan untuk mengevaluasi distribusi dosis efektif radiasi pada jaringan yang terlibat dalam pemeriksaan CT-Scan kepala di RS Hermina Bitung dan menilai kesesuaiannya dengan peraturan yang ditetapkan oleh Indonesia Diagnostic Reference Level (I-DRL).

Metode

Studi ini melibatkan 100 pasien, terdiri dari 50 laki-laki dan 50 perempuan. Data berupa nilai Dose Length Product (DLP) dikumpulkan dari masing-masing pasien dan dikonversi ke dosis efektif menggunakan kalkulator dosis radiasi.

Hasil

Hasil penelitian menunjukkan bahwa 6 dari 100 sampel melebihi batas dosis yang ditetapkan oleh Badan Pengawas Tenaga Nuklir (BAPETEN). Faktor-faktor yang mempengaruhi dosis efektif termasuk eksposi, berat badan, ketebalan objek, panjang daerah paparan radiasi (scan length),usia, bobot jaringan, sensitivitas jaringan, FOV, dan juga *pitch.* Meskipun demikian, rata-rata dosis efektif keseluruhan pasien masih sesuai dengan ketetapan I-DRL.

Kesimpulan

Faktor seperti jenis kelamin, dapat mempengaruhi dosis efektif yang diterima pasien. Nilai 75 percentile pada dosis efektif pemeriksaan CT-Scan kepala non kontras di RS Hermina Bitung sesuai dengan ketetapan I-DRL. Kalkulator dosis radiasi yang digunakan dapat diaplikasikan di Indonesia, namun masih membutuhkan peningkatan literasi informasi terkait penggunaannya.

Kata Kunci: CT-Scan; DLP; Kalkulator Dosis; Dosis Radiasi.

INTRODUCTION

In the world of health, the use of medical equipment is critical. The need for imaging in radio diagnostics continues to increase along with technological advances. Radiology installations provide medical care that utilizes ionizing and non-ionizing radiation.[1] Several medical device examinations require radiation sources to produce images, one of which is CT-Scan.[2] CT-Scan is an imaging tool or medical procedure to obtain images of the inside of an organ examined using X-rays. Compared to X-rays, CT-Scan obtains more detailed images because the resulting images are in the form of thin slices of the organ being examined.[3]

CT-Scan can provide image information from axial, coronal, and sagittal sections. The main principle of the CT-Scan is that the X-ray tube rotates stationary and emits X-rays consistently followed by the movement of the patient table, which produces many slices (multi slices) in one patient movement.[4] By its nature, when compared with conventional X-ray imaging techniques, MSCT has a higher radiation dose.[5] Even at low doses, it can cause damaging effects on DNA and potential deterministic effects such as skin injury, hair loss, cancer, and infertility, all of which can have negative impacts on health.[6]

CT-Scan is utilized for various types of examinations from head to toe. The most frequently performed CT-Scan examination is a head CT-Scan, reaching 60%, contributing 70% of radiation.[7] The head is a part of the body that has organs that are sensitive and at risk of radiation. Biological effects caused by radiation can be divided into stochastic effects and deterministic effects (non-stochastic).[8]

Research conducted by Soediatmoko (2011) produced doses received on head organs such as salivary glands ranging from 0.66 mSv – 0.8 mSv, brain 0.66 mSv – 0.8 mSv, for thyroid around 0.072 mSv – 0.33 mSv. It is estimated that a dose of 0.6 Gy is enough to cause thyroid cancer.[9] This figure is supported by the value set by (International Commission on Radiological Protection) ICRP 103 (2007) that the dose limit on the eye lens is 0.5 Gy with an equivalent dose of 15 mSv per year. Then, for the skin itself, the recommended radiation dose is 50 mSv per year. If the dose received exceeds this number, it can cause skin irritation, skin cancer, and even biological abnormalities.[10]

In CT-Scan examinations, efforts to reduce radiation doses and effects are carried out by estimating the correct dose given to patients using an optimization value reference called DRL. In this case, DRL for CT-Scan examinations is expressed as CTDIvol and DLP. CTDIvol is the output indicator value of the CT-Scan examination, and DLP is the output indicator value. However, in recent years, several weaknesses of CTDI in CT-Scan examinations have been found. First, CTDI is not suitable for wide-beam CT examinations because the dose distribution is spread after being measured through a 100 mm chamber ion pencil. Second, CTDI only shows the output dose of the CT scan, not the patient dose. This is because the patient dose depends on the output dose and also depends on the size of the patient.[11]

BAPETEN has created the latest DRL for Indonesia (Number: 1211/K/V/2021) known as IDRL (Indonesian Diagnostic Reference Level). The IDRL value for non-contrast head CT-Scan itself is CTDIvol of 60 mGy and for DLP of 1275 mGy*cm.[12] For ICRP itself, it recommends a head CT-Scan examination ranging from 1-2 mSv.10 According to previous research conducted by Sofiana and Noor (2013), the method used is to collect data such as DLP and CTDIvol, along with several parameters such as current strength, rotation time, and radiation exposure area. From the data above, four conclusions were found that the DLP value and empirical weighting factor affect the effective dose value, the higher the DLP value, the greater the effective dose. Adult male patients have an effective dose on a head CT scan of 2.42 mSv, while female patients have an effective dose of 2.08 mSv.[13]

As an optimization, Brian Nett, PhD, a principal of science at GE Healthcare, Assistant Professor at the University of Wisconsin Madison, and also as an educator on his website How Radiology Works created a simple and easy-to-use radiation dose calculation calculator. The use of this calculator is only by entering the Dose Length Product (DLP) data obtained from the CT scan examination data and the examination region. Then, the effective dose received by the patient on the head CT scan examination is obtained.[14]

From the data obtained from the Radiology Installation of Hermina Bitung Hospital, the number of head CT scan patients in the last 2 months has reached approximately 232 patients, out of 350 patients who underwent all examinations. From the many CT scan examinations, radiographers' knowledge of the radiation dose received by patients is still minimal. This is what supports the author in conducting this study so that awareness of the importance of providing radiation doses for examinations.

METHODS

The method used in this study is quantitative descriptive with an observational approach. Data collection was carried out retrospectively. The sample in this study was all patients with non-contrast head CT-Scan examinations from December 2023 to February 2024. Sampling used a non-probability sampling technique with a total sampling method.

The inclusion criteria were samples of 50 men and 50 women, samples aged between 20 and 65 years, and patients with non-contrast examinations. The exclusion criteria were samples under

20 years of age or over 65 years of age, patients with uncooperative conditions, patients with pregnancy, and patients before December 2023 and after February 2024.

Data analysis was carried out by collecting DLP (Dose Length Product) values from each sample. The data obtained was then processed by entering it into the radiation dose calculator on the How Radiology Works website. The way it works is by entering the DLP value, the body part being examined, and also the patient's age level. To obtain the appropriate results, the calculator also multiplies the DLP value by the empirical weight value (k). Then, the output value of the calculator is obtained in the form of an effective dose (mSv).

After the effective dose value is obtained, the data processing is continued using SPSS statistics to obtain the 50th percentile, 75th percentile, mean, median, minimum value, and maximum value, which are then compared with the exposure value set by I-DRL (Indonesia Diagnostic Reference Level).

RESULTS

Distribution of doses from maximum and minimum values, as well as mean, median, range, and percentile 75 for DLP and Effective Dose values in non-contrast head CT-Scan examinations at Hermina Bitung Hospital. Percentile 75 is based as a reference for I-DRL values of non-contrast head CT-Scan. Presented in tables 1 and 2.

Table 1. Distribution of DLP values and effective doses for all subjects.

Dose Distribution	DLP (mGy*cm)	Effective Dose (mSv)
Mean	1175	2.467
Median Range	1166	2.449
Percentile 75	478	1.005
Minimum	1236	2.596
Maximum	1017	2.135
	1495	3.140

Table 2. Distribution of effective doses for male and female subjects.

Dose Distribution	Effective Dose (mSv)	
	Male	Female
Mean	2.487	2.447
Minimum Maximum	2.169	2.135
	3.140	2.738

The results of the DLP value measurements and effective doses for all subjects in non-contrast head CT scans for the period December 2023 to February 2024, for further calculations of the 50th and 75th percentile values, which can be seen in Table 3 with the k value= 0.0021 mSv.mGy^{-1} .cm^{-1}.

Table 3. Comparison of the 50th percentile, and 75th percentile values of DLP and effective dose with the I-DRL value.

Description	DLP (mGy*cm)	Effective Dose (mSv)
Percentile 50 (Q2)	1166	2.449
Percentile 75 (Q3)	1236	2.596
I-DRL	1275	2.677

Based on the table above, the DRL value of the effective dose is stated in Figure 1.

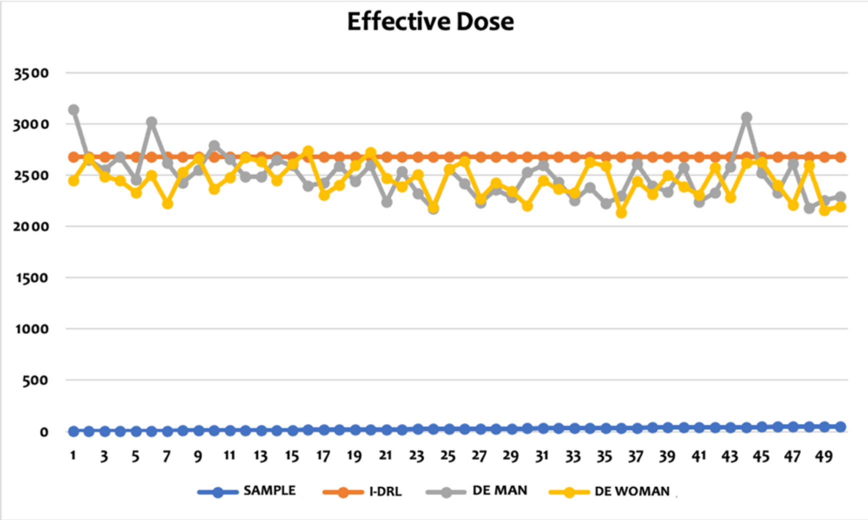

Figure 1. Graph of overall effective dose values for subjects

Based on Table 1, it is stated that the distribution of effective doses from all subjects of non-contrast head CT-Scan patients for the period December 2023 to February 2024 is a median value of 2,449 mSv, a mean of 2,2467 mSv, a minimum value of 2,135 mSv, a maximum value of 3,140 mSv, and the value at the 75th percentile (Q3) is 2,596 mSv.

Table 3 states that for the 50th percentile (Quartile 2) all subjects were obtained with an effective dose value of 2,449 mSv. From the results of the 75th percentile and 50th percentile, when compared with the I-DRL value that has been converted to an effective dose by multiplying the DLP value by the empirical weight of the head, it is found that the effective dose in the subject is still below the I-DRL value, which is 2,677 mSv.

At the 75th percentile, a smaller value is obtained with the dose value issued by the I-DRL. This is per the guidelines issued by BAPETEN in 2021 concerning Technical Guidelines for the Implementation of the Indonesian Diagnostic Guideline Level. Where the 75th percentile value (Quartile 3) is used as the maximum limit value for the DRL CT-Scan output, namely CTDIvol and DLP.

Based on Figure 1 on the effective dose value graph of the subjects, when compared with the effective dose value of I-DRL, it can be seen that there are 6 subjects who exceed the I-DRL value. Consisting of 4 men and 2 women. Table 2 states that the average effective dose value in men is greater than in women. This discussion is in accordance with previous research conducted by Sofiana et al. which stated that the dose in adult male patients is greater than in adult female patients in cases of non-contrast head CT-Scan examinations.[8]

DISCUSSION

From 232 subjects, taking into account a 95% confidence level and a 5% margin of error, a sample of 100 can be taken. The data is sufficient to determine the sample criteria. In this study, 6 samples exceeded the radiation dose limit set by I-DRL. This means that 6% of patients at Hermina Bitung Hospital for 2 months exceeded the radiation dose limit.

The difference in radiation dose values is influenced by several factors, including exposure factors consisting of kV and mA.[15] In the CT-Scan procedure, the kV used affects the radiation dose received by the patient. The level of X-ray voltage produced affects the amount of X-ray emissions produced to penetrate the object, and the level of X-ray voltage produced affects the intensity of the X-rays produced, which means that the radiation dose received by the patient is greater. The mA current used also affects the radiation dose produced, the number of electrons moving from the cathode to the anode per unit of time is affected by the X-ray current, which is the higher the X-ray current the more electrons move, which means the radiation dose received by the patient is also greater. [16]

Another factor is the length of the radiation exposure area (scan length). Where according to previous research, it states that for each examination, there are upper and lower size limits. The scan length used affects the DLP value and has a directly proportional relationship. The longer the scan is used, the more objects are exposed to radiation, which means that the DLP value can be increased. [7]

Body weight and age also affect the radiation dose value in non-contrast head CT-Scans. This was also conveyed by Siregar that there are a number of variables that affect the CTDIvol value and DLP value. As a result, the relationship between CTDIvol and DLP values to age and weight is not always directly proportional.[2]

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Stochastic effects are long-term effects, with examples such as genetic disorders and cancer. Deterministic effects are short-term effects with cases of radiation doses that exceed the dose limit value, for example, redness of the skin, hair loss, cataracts, and nausea and vomiting.[20]

The limitation of this study is that it is still necessary to sort out the parameters of the head CT-Scan examination. There are 2 types of examinations on the head CT-Scan, namely the head CT-Scan itself with the upper limit of the cranium apex, and the lower limit of the symphysis menthis os mandibula. Then there is a head CT-Scan with the upper limit of the apex and the lower limits of the base cranii. The difference in these examinations is based on the supporting diagnosis and the request of the referring physician. In this case, the author focuses the study on patients with head CT-Scan examinations with the upper limit of the cranium apex and the lower limit of the symphysis mentis.

Some head CT-Scan examinations with trauma cases are performed by extending the FOV. This is because the referring physician suspects a case of trauma to the cervical. With the current CT-Scan modality, the exposure factor is done automatically by the CT-Scan tool. Usually, the radiographer will reset the exposure factor by minimizing and calculating the DLP value, but this will result in less-than-optimal image quality.

CONCLUSION

The average effective dose value of all patients was 2614.50 mSv, while the average value of male subjects was 2689.90 mSv and female subjects was 1209 mSv. The 50th percentile value in the subjects was 2554 mSv. This is still below the standard set by BAPETEN.

There were 6 subjects who exceeded the I-DRL limit, consisting of 4 male subjects and 2 female subjects. In these subjects, the magnitude of the radiation dose value was caused by gender, because the size of the object between men and women was not the same. Other factors that affect the magnitude of the radiation dose received by the subject are scan length, body weight, exposure factor, age, tissue weight, tissue sensitivity, FOV, and also pitch.

As many as 6% of subjects exceeded the dose limit set by I-DRL, this is not normal and needs to be evaluated. Because excessive doses can provide stochastic effects (long-term effects) and deterministic (short-term effects). Even though the risk is small in a CT scan, it cannot be denied that it can happen.

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AUTHORS CONTRIBUTION

All authors contributed to the preparation of this manuscript.

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CONFLICT OF INTEREST

There is no conflict of interest among the authors of the manuscript.

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