ANALYSIS OF PATIENT FACTORS AND EXPOSURE PARAMETERS TO CTDIVOL AND DLP ON HEAD CT-SCAN AT TANJUNGPURA UNIVERSITY HOSPITAL

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ANALISIS FAKTOR PASIEN DAN PARAMETER PAPARAN TERHADAP CTDIVOL DAN DLP PADA CT-SCAN KEPALA DI RUMAH SAKIT UNIVERSITAS TANJUNGPURA

Abstrak

Penelitian ini bertujuan untuk menganalisis hubungan faktor pasien dan parameter paparan terhadap *Computed Tomography Dose Index Volume* (CTDIvol) dan *Dose Length Product* (DLP), serta mengevaluasi *Size-Specific Dose Estimate* (SSDE) pada pemeriksaan CT-scan kepala di Rumah Sakit Universitas Tanjungpura. Penelitian retrospektif ini menggunakan data rekam medis dari 115 pasien dewasa. Faktor pasien yang dianalisis meliputi jenis kelamin, usia, dan *Body Mass Index* (BMI), sedangkan parameter paparan meliputi tegangan tabung (kV) dan panjang pemindaian *(scan length)*. Analisis data dilakukan menggunakan uji statistik non-parametrik, yaitu uji Mann-Whitney dan korelasi Spearman. Nilai SSDE dihitung berdasarkan diameter efektif yang diperoleh dari pengukuran anteroposterior (AP) dan lateral (LAT) kranium. Hasil penelitian menunjukkan bahwa faktor pasien (jenis kelamin, usia, dan BMI) tidak memiliki hubungan yang signifikan dengan nilai CTDIvol maupun DLP ($p > 0,05$). Sebaliknya, parameter paparan terbukti berhubungan secara signifikan dengan dosis radiasi. Tegangan tabung (kV) memiliki korelasi positif yang kuat dengan CTDIvol ($r_s = 0,679$; $p < 0,001$) dan DLP ($r_s = 0,675$; $p < 0,001$). *Scan length* berkorelasi positif secara signifikan dengan DLP ($r_s = 0,591$; $p < 0,001$), namun tidak berhubungan signifikan dengan CTDIvol ($r_s = -0,122$; $p = 0,194$). Rata-rata SSDE sebesar 41,57 mGy, sedikit lebih rendah dibandingkan dengan rata-rata CTDIvol sebesar 41,78 mGy. Nilai *Diagnostic Reference Level* (DRL) lokal pada persentil ke-75 (P75) adalah 44,25 mGy untuk CTDIvol dan 796,40 mGy·cm untuk DLP. Kedua nilai tersebut masih berada di bawah nilai acuan nasional *Indonesian Diagnostic Reference Level* (I-DRL). Secara keseluruhan, variasi dosis radiasi pada CT-scan kepala lebih didominasi oleh pengaturan parameter teknis paparan dibandingkan dengan ukuran fisik atau karakteristik demografi pasien.

Keywords: CTDIvol, DLP, SSDE, CT-scan Kepala, Faktor Pasien, Parameter Paparan, Dosis Radiasi.

ANALYSIS OF PATIENT FACTORS AND EXPOSURE PARAMETERS TO CTDIVOL AND DLP ON HEAD CT-SCAN AT TANJUNGPURA UNIVERSITY HOSPITAL

Abstract

This study aims to analyze the relationship between patient factors and exposure parameters with Computed Tomography Dose Index Volume (CTDIvol) and Dose Length Product (DLP), as well as to evaluate Size-Specific Dose Estimate (SSDE) in head CT examinations at Tanjungpura University Hospital. This retrospective study used medical record data from 115 adult patients. The patient factors analyzed included sex, age, and Body Mass Index (BMI), while the exposure parameters included tube voltage (kV) and scan length. Data analysis was performed using non-parametric statistical tests, namely the Mann-Whitney test and Spearman correlation. SSDE values were calculated based on the effective diameter obtained from anteroposterior (AP) and lateral (LAT) cranial measurements. The results showed that patient factors (sex, age, and BMI) were not significantly associated with CTDIvol or DLP values ($p > 0.05$). In contrast, exposure parameters were significantly associated with radiation dose. Tube voltage (kV) showed a strong positive correlation with CTDIvol ($r_s = 0.679$; $p < 0.001$) and DLP ($r_s = 0.675$; $p < 0.001$). Scan length showed a significant positive correlation with DLP ($r_s = 0.591$; $p < 0.001$), but was not significantly associated with CTDIvol ($r_s = -0.122$; $p = 0.194$). The average SSDE was 41.57 mGy, slightly lower than the average CTDIvol of 41.78 mGy. The local Diagnostic Reference Level (DRL) values at the 75th percentile (P75) were 44.25 mGy for CTDIvol and 796.40 mGy·cm for DLP. Both values were below the national reference values of the Indonesian Diagnostic Reference Level (I-DRL). Overall, radiation dose variation in head CT examinations was more strongly associated with technical exposure parameters than with patient physical size or demographic characteristics.

Keywords: CTDIvol, DLP, SSDE, Head CT-scan, Patients' Factors, Exposure Parameters, Radiation Dose.

PREFACE

Praise be to Allah SWT for His blessings and guidance so that the author can complete the thesis with the title **"ANALYSIS OF PATIENT FACTORS AND EXPOSURE PARAMETERS TO CTDIVOL AND DLP ON HEAD CT-SCAN AT TANJUNGPURA UNIVERSITY HOSPITAL".** This thesis was prepared as one of the requirements to obtain a Bachelor of Science degree in the Physics Study Program, Faculty of Mathematics and Natural Sciences, Tanjungpura University of Pontianak. The author realizes that in the preparation of this thesis it is inseparable from the help of various parties either directly or indirectly. Therefore, the author would like to thank the:

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CHAPTER I
INTRODUCTION

1.1 Background

Computed Tomography (CT) has become one of the most essential medical imaging modalities in modern clinical practice. The main advantage of CT-scan lies in its ability to produce images of anatomical transverse sections of the body with high spatial resolution in a very short acquisition time. In particular, the CT-scan examination of the head occupies a crucial position as the gold standard for initial diagnostic evaluation in various cases of neurological emergencies, such as stroke, head trauma, tumors, and vascular disorders. Its ability to visualize hard and soft tissues with high precision in a relatively short time makes it a top choice in both emergency and radiology installations (Hsieh and Flohr, 2021).

Although it provides significant diagnostic benefits, the utilization of X-rays in CT systems makes it the largest contributor to radiation doses in the field of diagnostic radiology. Increased uncontrolled radiation exposure has the potential to trigger ionization processes in biological tissues that can pose two main types of risks, namely deterministic and stochastic effects. Deterministic effects, such as damage to the skin or tissues, can occur when the dose received by the patient exceeds a certain threshold. On the other hand, stochastic effects, such as long-term cancer risk, can occur probabilistic even at low dose exposure in the absence of a completely risk-free threshold. Therefore, the application of strict radiation protection rules through the ALARA (As Low as Reasonably Achievable) principle is absolutely necessary in every inspection procedure. The application of this principle aims to guarantee that the radiation exposure received by the patient is suppressed to the lowest possible level, without compromising the quality of the diagnostic images required (Dance *et al.*, 2014).

As a form of implementation of the ALARA principle, monitoring and optimization of radiation dose on the CT-scan scanner is carried out using the main indicators, namely Computed Tomography Dose Index Volume (CTDIvol) and Dose Length Product (DLP). CTDIvol represents the estimated average dose a

patient receives per slice volume, while DLP describes the total radiation energy absorbed along the scan area. To ensure that the doses administered by hospitals remain within reasonable limits, the Nuclear Energy Supervisory Agency (BAPETEN) has established a national reference regulation known as the Indonesian Diagnostic Reference Level (I-DRL). Based on ("Nuclear Energy Supervisory Agency," 2021), the I-DRL reference value limit for non-contrast head CT-scan examination in adult patients was set at 60 mGy for the CTDIvol indicator and 1275 mGy·cm for DLP. Therefore, periodic evaluation of local DRLs in radiology installations is a crucial step to assess the level of compliance and optimization of examination protocols against these national standards.

Although the I-DRL reference value has been established nationally, the amount of radiation dose patients receive in practice may vary. This variation is theoretically often associated with exposure parameter factors such as tube voltage (kV) and scan length as well as the demographic and anthropometric characteristics of the patient, which include sex, age, and Body Mass Index (BMI). However, the degree of correlation and influence of each of these factors on dose indicators such as Computed Tomography Dose Index Volume (CTDIvol) and Dose Length Product (DLP) often show dynamic characteristics. In terms of dose evaluation based on body size, research by (Abuzaid, 2025) evaluate the use of Size-Specific Dose Estimate (SSDE) as a correction method to estimate radiation doses more specifically to individual anatomical conditions. The findings are reinforced by research (Dewanti *et al.*, 2024), which suggests that technical parameters have a very strong correlation to dose output, while body characteristic variables show varying relationship dynamics on head CT-scan examination. Therefore, specific testing of the extent of the relationship between patient factors and exposure parameters to radiation dose indicators in hospitals is important to support patient safety evaluation.

Until now, studies that comprehensively combine analysis of the relationship between patient factors and exposure parameters using a non-parametric statistical approach as well as specific evaluation based on body size (SSDE) on head CT-scan examinations are still limited. In fact, the combination of the two approaches

is crucial to provide in-depth information on the extent to which technical and anthropometric factors affect the factual output of doses. Based on these conditions, this study was conducted by combining non-parametric statistical analysis and SSDE evaluation to examine patient factors and exposure parameters to CTDIvol and DLP values in the head CT-scan examination. Thus, this study is expected to provide a comprehensive picture while supporting the optimization of radiation protection and patient safety in accordance with the As Low as Reasonably Achievable (ALARA) principle.

1.2 Problem Formulation

Based on the background described, the formulation of the problem in this study is as follows:

1. How do patient factors (*sex, age,* and BMI) relate to CTDIvol and DLP?
2. How do exposure parameters (kV and scan length) relate to CTDIvol and DLP?
3. How does the SSDE dose estimate compare to the CTDIvol dose indicator?
4. How do the CTDIvol and DLP values compare to the Indonesian Diagnostic Reference Level (I-DRL) reference value?

1.3 Problem Limitations

The limitations of the problem in this study are as follows:

1. The research was limited to the CT-scan modality at the Radiology Installation of Tanjungpura University Hospital.
2. The variables analyzed included patient factors, namely sex, age, and BMI, as well as exposure parameters, namely tube voltage (kV) and scan length.
3. Radiation dose analysis was limited to the CTDIvol and Dose Length Product (DLP) indicators, while the Size-Specific Dose Estimate (SSDE) was used as an additional indicator to compare dose estimates that had taken into account the patients' size with the CTDIvol value.
4. The research data is retrospective and was obtained from medical records and head CT-scan examination data from 115 patients who met the research criteria.

5. Statistical analysis includes descriptive statistics, Shapiro–Wilk normality test, Spearman correlation test, and Mann–Whitney test according to data type, scale, and distribution.
6. The evaluation of the radiation dose level was carried out by determining the local Diagnostic Reference Level (DRL) based on the 75th percentile (P75) of CTDIvol and DLP, then compared with the value of the Indonesian Diagnostic Reference Level (I-DRL) that is appropriate for head CT examination.

1.4 Research Objectives

Based on the formulation of the problem, the objectives of this research are as follows:

1. Analyze the relationship between patient factors and CTDIvol and DLP values.
2. Analyze the relationship of exposure parameters to CTDIvol and DLP values.
3. Compare and evaluate the value of CTDIvol against SSDE.
4. Compare local radiation dose levels (CTDIvol and DLP) with the corresponding national I-DRL reference values.

1.5 Research Benefits

The expected benefits of this research are as follows:

1. For science:

This research is expected to enrich studies in the field of medical physics and diagnostic imaging, especially related to the association of patient factors and exposure parameters with CTDIvol and DLP as well as SSDE evaluation as a patient-specific dose estimate on head CT scan.

2. For hospitals:

This research is expected to be an evaluation material in optimizing the head CT scan protocol based on CTDIvol, DLP, and SSDE analysis, so that it can support the application of radiation protection according to the ALARA principle.

3. For patients

This research is expected to support the implementation of a more optimal CT scan protocol, so that patients obtain the lowest possible radiation exposure while maintaining good diagnostic examination quality.