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Radiation Dose Optimization: Range Configuration on Computed Tomography Scans of Non-Contrast Head Scans with Hemiparese Cases

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ABSTRACT

Approximately 80% of stroke patients experience weakness/hemiparesis on one side of the body due to vascular abnormalities in certain hemispheres. If hemiparese is not treated immediately, it can cause permanent disability. Supporting examination that can be used to diagnose hemiparese is a non-contrast head CT scan. There are several ranges that can be applied to the examination. This affects the dose received by the patient. This study aims to compare the radiation dose (CTDIvol and DLP) in non-contrast head CT scan examination in hemiparese cases between the range from vertex to sinus maxillaris and the range from vertex to basic cranii. The research was conducted at KRT Setjonegoro Wonosobo Hospital in December 2023 using quantitative method. Data were obtained from a non-contrast head CT scan examination with hemiparese cases using the range vertex to sinus maxillary and range vertex to basic crani. Results: In the head CT Scan examination of hemiparese cases, the CTDIvol value for the range Vertex to sinus maxillaris and the range Vertex to basic cranii is 45.5 ± 12.6 mGy and 48.8 ± 14.6 mGy, while for the DLP for the range Vertex to sinus maxillaris is 609.8 ± 47.9 mGy.cm and for the range Vertex to basic cranii is 878.9 ± 42.1 mGy.cm. CTDIvol value is found to have no significant difference, but for the DPL value there is a significant difference in the non-contrast head CT scan examination without contrast with hemiparese cases The 2 CTDIvol and DLP values are still in accordance with the DRL recommendations recommended by Nuclear Energy Regulatory Agency (BAPETEN).

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1. INTRODUCTION

About 80% of patients who have had a stroke will feel weakness/hemiparese on one side of their body. Stroke patients experience weakness in the hands and feet, which leads to a negative effect on muscle contractions. The cause of this reduced muscle contraction is due to a lack of blood supply to the back and middle of the brain, which inhibits the transmission of key signals between the brain and spinal cord. Nerve disorders can increase due to swelling of the brain (cerebro edema) during a stroke, causing an increase in brain cavities, as well as causing more damage to brain tissue. The golden time for treatment of stroke patients is ≤ 3 hours, so complete and optimal treatment is needed to achieve success [1]. The disadvantage of hemiparese is that it can cause permanent disability if not treated immediately [2]. Evaluation of hemiparese can be seen based on the patient's muscle

weakness. To identify damaged areas of the brain in more detail, it can be done using non-contrast brain imaging (CT scan) of the head.

CT scan is the fastest and most useful imaging method to identify or differentiate brain hemorrhage and identify acute ischemic after infarction (dead tissue). This method uses ionizing X-rays as a light source that is digitally processed by a computer to produce an axial image of the object from various angles .[3] The advantages of the CT Scan modality are very important in the radiodiagnostic process. But it is important to note that CT scans produce significantly larger doses of radiation when compared to the more common conventional radiology (X-rays). The dose of CT Scan examination can be said to be almost 100 times larger when compared to conventional radiological examinations [4];[5]. CT scans provide as much as 70% of the total dose in medical imaging, with an effective radiation dose of between 5 and 50 mSv per examination of each organ imaged, as CT scans provide primary and secondary doses at each scan.

The dose applied to each CT scan varies, and dose information can be found on the console after the examination is complete, in the form of CTDIvol and DLP. CTDIvol is the output dose indicator of the CT scan while DLP is in charge of recording the overall dose value during the examination. From the research that has been carried out by Annisah. R (2023) [6] , stated that the CTDIvol value in the head examination was higher than the CTDIvol value in the thorax and abdominal organs. For head examination, the patient's CTDIvol was around 31.91 mGy, while the CTDIvol in the thorax was around 11.3 mGy and the CTDIvol in the abdomen was around 20.99 mGy. The radiation dose received by patients when undergoing a CT scan is inevitable. Therefore, the risk of biological effects on patients as a result of radiation use is also increased. Although the risk to every organ is not the same, increased radiation exposure in humans has the potential to pose greater public health problems, both now and in the future.

High and low doses of radiation can cause changes in the body's biological systems and can increase the risk of cancer in patients [7]. High doses of radiation can cause health problems that occur due to DNA damage caused by these doses resulting from the use of CT scans. The higher the dose received, the severity of the effects will also increase, while for low doses, even if no change is seen, the dose still has the potential to cause effects later in life. If the accumulated low dose increases, the potential for effects that will appear in the future will also increase [8]. The Nuclear Energy Supervisory Agency (BAPETEN), has released the latest Diagnostic Level Reference (DRL) for Indonesia which is known as the Indonesian Diagnostic Level Reference (I-DRL) 2021. I-DRL is a guide to the maximum dose of both CTDIvol and DLP that patients can accept. According to I-DRL, the Indonesian Diagnostic Reference Level (IDRL) value, especially for non-contrast head CT scans, is 60 mGy for CTDIvol and 1275 mGy.cm for DLP [9].

There are several ways to reduce the dose received by patients, one of which is by setting the range. But the range setting also affects the image produced. Theoretically, according to Mahendra. R, (2020) [10] the parameters used should be in accordance with pathological abnormalities, by utilizing a range and a slice thickness of 5-10 mm from vertex to basic cranii. On the other hand, according to Utami AP, (2018) [11], CT scan of the head should be done with two ranges, where the first range starts from basic cranii to pars petrosum with a slice thickness of 2-5 mm, while the second range covers pars petrosum to vertex with a slice thickness of 10 mm. However, the authors found that the CT protocol of head scan without contrast at KRT Setjonegoro Wonosobo Hospital with hemiparese cases was carried out scanning the area from the vertex to the maxillary sinus with a slice thickness of 5 mm. Based on this presentation, the author aims to analyze the comparison of doses in the form of CTDIvol and DLP received by patients on non-contrast head CT scan examination with hemiparese cases between the scanning range from the vertex to the maxillary sinus and the range from the vertex to the basic cranii.

2. RESEARCH METHOD

The research was carried out using quantitative methods. Data was obtained from the results of non-contrast head CT scan examination with hemiparese cases that used range vertex to maxillary sinus and range vertex to basic cranii. The research was conducted at KRT Setjonegoro Wonosobo Hospital in December 2023 using the Toshiba Multislice CT Scanner Aqualition Lightning CT Scan tool, serial number 8B123. The data taken were CTDIvol and DLP values in the non-contrast head CT scan examination in the case of hemiparese between the range from the vertex to the maxillaris sinus and the range from the vertex to the basic cranii. The inspection was carried out with a slice thickness of 5 mm, scan time of 0.75s, voltage of 120 kV, 200 mAs and pitch of 0.55.

The data obtained in the form of CTDIvol and DLP were then statistically analyzed using an independent T Test. CTDIvol and DLP data on non-contrast head CT scan examination with a range of vertex to maxillary sinus were also statistically compared with the national DRL value which is the dose recommendation, both CTDIvol and DLP on non-contrast head CT scan examination using one sample T test.

3. RESULT AND DISCUSSIONS

This research was conducted at KRT Setjongeoro Wonosobo Hospital which is one of the hospitals with plenary accreditation. The study aimed to assess the dose, expressed in the form of CTDIvol and DLP on a CT

scan of the head without using contrast for the use of a range from vertex to maxillaris sinus and compared to a range from vertex to basic cranii. The characteristics of the research sample in this study can be seen in **Table 1**.

Table 1. Characteristics of Research Sample

Gender	%
Man	50
Woman	50

Based on **Table 1**, it is known that the number of research samples when categorized by gender has the same percentage, namely 50% males and 50% females.

The results of dose measurements in the form of CTDIvol and DLP values on the non-contrast head CT scan examination can be seen in **Table 2**.

Table 2. Data on The Average Value of Ctdivol and DLP in The Non-Contrast Head SCT Scan Examination

Range Indicator	CTDIvol (mGy)	DLP (mGy.cm)
Vertex to *maxillaris sinus*	45.5 ± 12.6	609.8 ± 47.9
Vertex to *basic cranii*	48.8 ± 14.6	878.9 ± 42.1[a]

[a]there was a significant difference with group1($p<0,05$)

Based on **Table 2** with different range length variations, namely the first range from vertex to maxillaris sinus and the second range from vertex to basic cranii produces different CTDIvol and DLP average values. The CTDIvol values for the Vertex range to maxillaris sinus and the Vertex range to basic cranii are 45.5 ± 12.6 mGy and 48.8 ± 14.6 mGy, while the DLP for the Vertex range to maxillaris sinus is 609.8 ± 47.9 mGy.cm and for the Vertex range to basic cranii is 878.9 ± 42.1 mGy.cm.

Table 2 also shows that in the CTDIvol variable, the CT scan of the head is non-contrast with the hemiparese case between the use of range vertex to maxillaris sinus and range vertex to basic cranii has a p-value > 0.05, so it can be concluded that there is no significant difference in the CTDIvol value of the non-contrast head CT scan examination with the hemiparese case between the range from the vertex to the maxillaris sinus and the range from the vertex to the basic cranii. As for the DLP variable, the p-value < 0.05 so it can be concluded that the DLP on the CT scan of the head without contrast with the hemipaese case between the range of the vertex to the maxillaris sinus and the range of the vertex to the basic cranii there is a significant difference.

The CTDIvol value that does not differ significantly occurs because the CTDIvol is an estimate of the average value of the dose absorbed in the body volume of the scanned patient, so the CTDIvol value is not affected by the range. CTDIvol is useful for describing the dose efficiency of a CT Scan protocol and for comparing between scan models [12].

The range of the CT Scan examination affects the scan length carried out on the examination, so that the range will affect the value of the DLP which is the multiplication between the CTDIvol and the scan length. This is consistent with the findings of a study conducted by Kristinayanti et al., (2019) [13] which concluded that the larger the scan length, the higher the DLP value. The main cause of the significant difference between DLP values on CT scan examination without head contrast between the range of vertex to the maxillaris sinus and the range of the vertex to the basic cranii.

The results of the comparison between the CT scan of the non-contrast head and the hemiparese case between the range from the vertex to the maxillary sinus and the DRL that have been determined by the government can be seen in **Table 3**.

Table 3 shows that the average value of the non-contrast head CT scan between the range from vertex to maxillaris sinus has a CTDIvol and DLP that is smaller than the DRL value that has been set by the government.

Statistically, based on table 3, it can be concluded that the CTDIvol and DLP values in the non-contrast head CT scan examination between the Vertex range to the maxillaris sinus and the DRL of the non-contrast head examination have significantly different values. The CTDIvol and DLP values on the CT scan of the head between the Vertex range to the maxillary sinus are in accordance with the recommendations recommended by BAPETEN. So it can be concluded that the examination has a dose that is in accordance with the recommendations by BAPETEN.

Table 3. Results of Calculation of The Average Dose and DRL Values

Types of Examinations	CTDIvol (mGy)	DLP (mGy.cm)
CT scan of the head non-contrast between the range	45.5 ± 12.6[b]	609.8 ± 47.9[b]

Types of Examinations	CTDIvol (mGy)	DLP (mGy.cm)
from the vertex to the maxillary sinus		
DRL CT examination non-contrast head scan	60	1275

[b] indicates that there is a significant difference with group 2 ($p < 0,05$)

4. CONCLUSIONS

CTDIvol and DLP in the CT scan of the non-contrast head of hemiparese cases between the range of vertex to sinus maxillaris and range of vertex to basic cranii at KRT Setjonegoro Wonosobo Hospital had a CTDIvol value that was not significantly different, namely 45.5 ± 12.6 mGy, but for the DLP value there was a significant difference, namely 609.8 ± 47.9 mGy.cm. The CTDIvol and DLP values are still in accordance with the DRL recommendation standards recommended by Nuclear Energy Regulatory Agency (BAPETEN). And the recommendations from this research are utilizing optimized scanning protocols can significantly reduce radiation doses without compromising diagnostic quality. For instance, adjusting scan length can lower the delivered dose.

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