VOL. 15, NO. 6, MARCH 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

EFFECT OF HIGH VOLTAGE USAGE ON RADIATION ABSORPTION DOSE RECEIVED BY PATIENTS DURING CRANIUM EXAMINATION WITH A GRID

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ABSTRACT

A study on the analysis of radiation adsorption dose during cranium examination with a grid was carried out at the Radiology Installation of Raden Mattaher Regional Hospital, Jambi. This study aims to determine the effect of high voltage on the radiation adsorption doses received by patients during cranium examinations with a grid and to compare the absorbency dose values obtained on the basis of standard stresses. Results indicate the effect of radiation absorbance dose on voltage. When the utilised voltage (kV) is high, the value of the produced radiation absorbance dose will be small. In the high voltage (kV) irradiation technique with phantom cranium objects, the measured dose range is 0.0856012-0.09441567 mGy. In standard irradiation (kV), the measured dose range is 0.0642225-0.3034403 mGy. The radiation absorbance dose value received by the patients during cranium examination at the Radiology Installation of the Raden Mattaher Regional General Hospital in Jambi is still far below 0.4 mGy, which is the maximum limit allowed by the Nuclear Energy Supervisory Agency.

Keywords: medical-physics, radiology, absorbance dose, irradiation technique.

INTRODUCTION

In the medical field, various fields of examination support are required when diagnosing a disease and one of these fields is radiology. The radiology service unit is a medical support installation associated with the study and application of various imaging technologies using ionising radiation sources [1]. Cranium is an organ of the human skull that is difficult to penetrate through X-rays. The cranium bone is a protective bone that preserves the brain, which is responsible for the body's coordination system to function normally. The cranium inspection process requires a high voltage (kV) or high kV technique. This technique corresponds to a checking approach that uses a variation of the irradiation value in the form of high voltage rate with compensation that decreases the values of electric current and time (mAs). In practice, the aforementioned technique is widely used for adult cranium and lumbar examinations. The use of high voltage (kV) in patients can help obtain a short examination time, and the received radiation dose is small. This finding is in accordance with the 'as low as reasonably achievable' principle, which implies that every utilisation of radiation sources always requires the optimal dose reception for patients, radiation workers and the community [2].

Previous studies have investigated the effect of high voltage (kV) on the dose received by patients during lateral lumbar examination. A grid is used to analyse the value of scattering radiation doses during lateral lumbar photo examination by using standard voltage (kV) and high kV techniques. In a study on the use of high voltage (kV) techniques with pantomic objects on lateral lumbar examination, the measured dose range was 0.258-0.802 mGy. The use of standard voltage (kV) techniques results in a dose range of 0.917-1402 mGy [3].

The present study aims to determine the effect of high voltage on radiation absorption doses received by patients during cranium examinations with a grid. This study will also compare the absorbency dose values obtained with standard stresses and doses issued by the Nuclear Energy Supervisory Agency (BAPETEN) number 8 of 2011. Such tasks are initiated to ensure the safety of patients who are undergoing radio diagnostic examinations at the Radiology Installation of Raden Mattaher Regional Hospital.

MATERIAL AND METHOD

This study was conducted at the Radiology Installation of Raden Mattaher Jambi Hospital in February to March 2019. The hospital is located on Jalan Lieutenant General Suprapto No. 31, Telanai Pura, Jambi City. The tools and materials used in this study include X-ray planes, X-ray tapes, PM1610 dosimeters, grid and phantom cranium. Before carrying out the irradiation, the object's position needs to be adjusted to facilitate the implementation of irradiation on a certain part. In this study, the phantom cranium corresponds to in the anterior-posterior projection position. The object is straight in the middle of the tape lined with a grid on the examination table. The head is positioned perpendicular to the cassette. The centre of the X-ray is perpendicular to the cassette with a minimum distance of 100 cm. The voltage used in this study is high, which ranges from 90-100 kV because the X-ray radiation will penetrate a hard object (cranium). The 10 kV rule provides that if the voltage increases to 10 kV, then the electric current will decrease by 50% from the original value, and the high voltage set will range from 90-150 kV [4].

VOL. 15, NO. 6, MARCH 2020 ISSN 1819-6608
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The dose value is influential on the increase in the obtained voltage. This notion indicates that the dose between the high and the standard voltage techniques can be compared. The amount of dose obtained from direct exposure to the object is noted on dosimeter PM1610. The resulting dose value on dosimeter PM1610 is recalculated using Equation 1 to produce a voltage value at high voltage irradiation (kV) [5].

$$\left[\frac{kV_1}{kV_2}\right]^4 \times \mathrm{mAs}_1 = \mathrm{mAs}_2 \tag{1}$$

where kV1 is the initial voltage before it is changed, mAs1 is the initial current value before it is changed, kV2 is the voltage after it has been changed, and mAs2 is the current value after it has been changed.

The hypothesis utilised in the statistical tests using the simple linear regression method is presented as follows: The significance and probability values are compared. Meanwhile, the hypothesis used in statistical tests via a simple linear regression test is stated as follows: If the significance value is <0.05, then variable X affects variable Y. If the significance value is >0.05, then variable X has no effect on variable Y. In comparison with the t value with t table, if the value of t count > t table, then variable X affects variable Y. If the value of t arithmetic < t table, then variable X has no effect on variable Y.

RESULT AND DISCUSSIONS

Measurement results of radiation absorption absorbency with standard voltage irradiation

Table-1 presents the results obtained from the measurement of the average radiation absorbance dose for irradiation using standard stresses. The table presents that the average radiation absorbance dose of the five variations shows the average results of various radiation absorbency doses. However, the difference between the average radiation absorption doses at each voltage value (kV) is minimal. The table also shows the radiation absorbance dose values with standard voltage irradiation parameters. The average value of the radiation absorbance dose of the standard voltage irradiation parameters varies. Specifically, the produced radiation absorbance dose is small when the used voltage (kV) is high.

Table-1. Average value of radiation absorbance dose with standard voltage (kV).

Voltage (kV)	Average absorbed dose (mGy)
70	0.30344
72	0.14909
74	0.09442
76	0.07688
80	0.06422

Radiation absorption dose measurement results with high voltage parameters

Table-2 illustrates the results obtained from the measurement of the average radiation absorbance dose for irradiation using high voltage. The table exhibits that the average value of radiation absorbance dose of the five variations shows the average results of various radiation absorbency doses. However, the difference between the average radiation absorption doses at each voltage value (kV) is minimal. The table also demonstrates the radiation absorption dose values with high voltage irradiation parameters.

Table-2. Average value of radiation absorbency dose with high voltage parameters.

Voltage (kV)	Average absorbed dose (mGy)
90	0.09442
92	0.09121
94	0.08858
96	0.08741
100	0.08560

In the high voltage technique, the tube current value (mAs) is calculated using Equation (1), which refers to the voltage generated at the standard voltage. The calculation results can be used as a reference value of irradiation and will be used in subsequent high voltage techniques. Under certain conditions, the choice of obtaining the value of the tube current (mAs) is not found on the radiographic plane.

In Table-2, the measurement results show that the absorption dose is strongly influenced by the exposure factor. Accordingly, the high voltage provisions apply. That is, the permeability of the beam to the organ will increase with the voltage. The mAs is reduced below the dose amount with the increase in the compensation for the voltage (kV).

The research and data analytical results indicated that the radiation absorbance dose value is influential on the increase in tube voltage. Accordingly, the dose value at each voltage increase used can be determined. From this concept, the values of the voltage and the radiation absorbency doses can be used as references. This reference is intended to determine at what voltage the radiation dose can be minimised when irradiation is carried out during cranium inspection.

Comparison results of the radiation absorption doses on the parameters of high voltage irradiation, standard voltage and BAPETEN

Figure-1 shows the measurement result of the average radiation absorption dose for each voltage variation against the maximum recommended dose allowed by BAPETEN. The graph manifested that each average value of the absorption dose at each voltage value is still below the maximum one allowed by BAPETEN.

VOL. 15, NO. 6, MARCH 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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The dose limit value refers to the maximum dose allowed by BAPETEN that can be received by radiation workers, patients and members of the public within a certain period of time without causing significant genetic and somatic effects caused by the use of X-ray radiation. The maximum absorption dose limit determined by BAPETEN during cranium examination is 0.4 mGy [4].

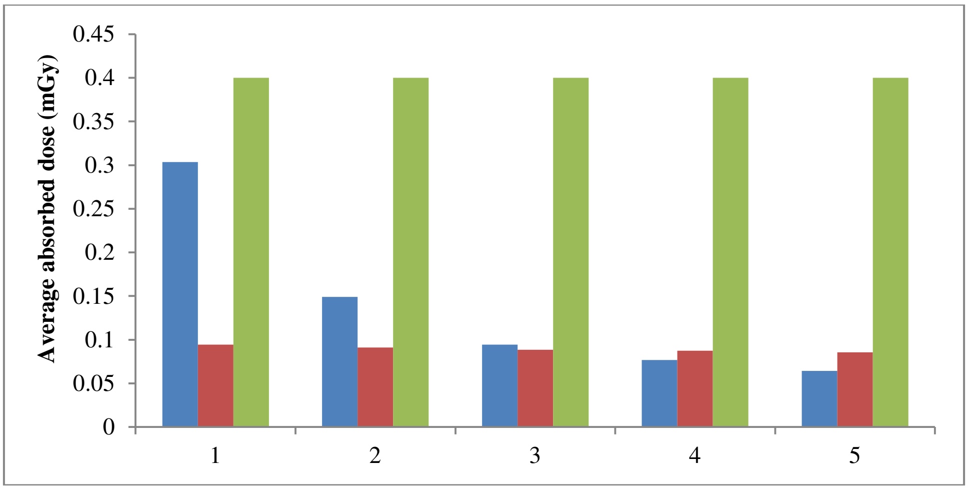

Figure-1. Comparison graph of the radiation absorption doses on high voltage irradiation techniques (red), standard stresses (blue) and dose limits set by BAPETEN (green).

Analytical test results based on a simple linear regression method

The tables and graph exhibit that the standard voltage for the variable X (voltage) significantly affect variable Y (dose) in the cranium inspection technique at the Radiology Installation of Raden Mattaher Hospital in Jambi. This notion is demonstrated by the results of the t test calculation of 2.538, whilst the table is 2.1603 at a significance level of 5% or 0.05. This finding indicates that H1 is accepted. The linear regression equation Y = -0.0211X + 1.7061 is also obtained (Figure-2a). The equation corresponds to the linear regression formula Y = a + Bx, where Y is the symbol of the dependent variable, a is constant and, b is the regression coefficient for the independent variable (X). The t test results indicate that variable Y influences variable X. Specifically, H1, which is the influence of the voltage on the absorption dose received in the cranium inspection technique, is accepted; by contrast, H0, which provides that the voltage has no effect on the absorption dose received through cranium inspection technique, is rejected.

Furthermore, the standard voltage for variable X (voltage) significantly affect variable Y (dose) in the cranium inspection technique at the Radiology Installation of Raden Mattaher Hospital in Jambi. This finding is demonstrated by the t test calculation results of 5.346. The table presents 2.1603 at a significance level of 5% or 0.05. This circumstance means that H1 is accepted. A linear regression equation Y = = −0.009X + 0.1699 is also obtained (Figure-2b). The equation corresponds to the linear regression formula Y = a + Bx, where Y is the symbol of the dependent variable, a is constant and, b is the regression coefficient for the independent variable (X). The t test results manifest Y variable influences X variable. In other words, H1, which is the influence of voltage on the absorbed dose received during the cranium inspection technique, and rejecting H0 have no effect of the voltage on the absorbed dose received on cranium inspection technique. This finding shows that the exposure factor is influential on the absorption dose of the produced radiation. Thus, the difference from the average value of the absorbed dose produced is due to the influence of not only the exposure factor but also the thickness of the used object [5].

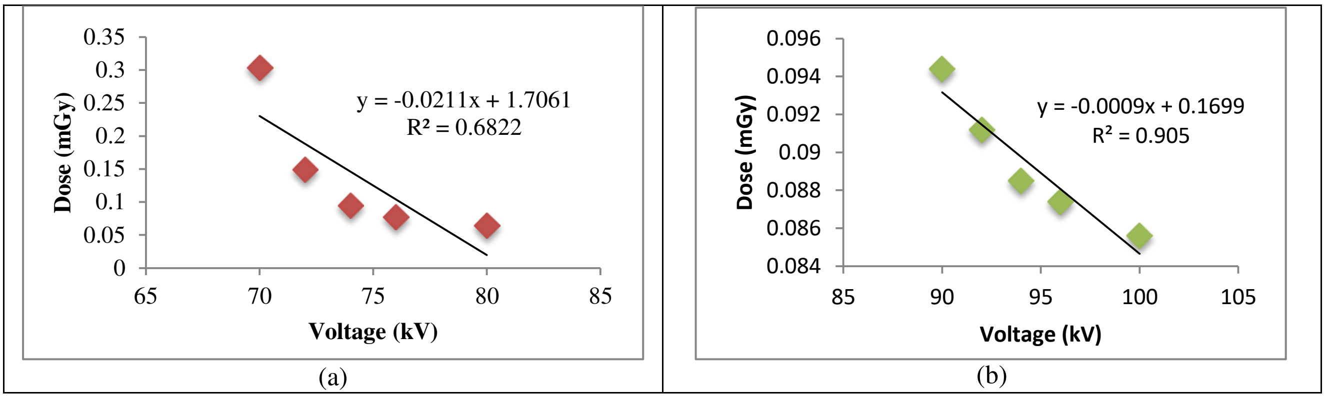

Figure-2. Graph of linear regression equation; (a) standard voltage, (b) high voltage.

CONCLUSIONS AND RECOMMENDATIONS

The research results on the analysis of the effect of high voltage on radiation absorbance dose on cranium inspection with a grid indicated that the value of the produced absorption radiation dose will be small when the used voltage (kV) is high. This finding is attributed to cranium, which is a hard organ, and X-rays exhibit difficultly in penetrating it. In the high voltage (kV) irradiation technique with phantom cranium objects, the measured dose range is 0.0856012-0.09441567 mGy. The measured dose range in the standard irradiation (kV) irradiation technique is 0.0642225-0.3034403 mGy.

This study suggests conducting further research for producing an optimal measurement of the radiation absorption dose. Cranium examination should be carried out using a high voltage value because the resulting dose is lower than that for the standard one. Further research also needs to be performed by testing the image quality (density and contrast) radiography of the high and standard voltage irradiation techniques.

ACKNOWLEDGEMENTS

The authors would like to thank the Universitas Jambi for funding and SERI-UKM for support.

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