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Analysis of the Effects of Variation of Phantom Diameter on Radiation Dose on Image Dicom CT Scan Using IndoseCT

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ABSTRACT

CT-Scan is one of the imaging modalities in the field of radiodiagnostics that can produce axial, coronal, and sagittal slices of the object or patient performing the examination. CT-Scan can be applied to diagnose trauma in cancer cases. The use of CT-Scan aircraft certainly provides a fairly large radiation dose compared to other diagnostic imaging modalities (Bushberg, 2012). This study aimed to determine the effect of the thickness (diameter) of the object on the radiation dose. This study's benefit is providing accuracy in receiving the body's absorbed dose on CT-Scan examination. This research is experimental. The study used a sample of 5 phantoms with variations in the diameter of 8 cm, 16 cm, 24 cm, 32 cm, and 40 cm. The data is obtained from the phantom scan results, which are inputted into the IndoseCT program. The data generated by IndoseCT will be analyzed regarding the amount of radiation dose received by each phantom size. The final result expected from this research is the evaluation of measurement or monitoring of doses to patients who can support radiation protection programs in ensuring patient safety.

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1. INTRODUCTION

CT-Scan is one of the imaging modalities in the field of radiodiagnostics that can produce axial, coronal, and sagittal slices of the object or patient who is doing the examination. This makes it possible to show each slice's internal body parts/organs. CT-Scan can be applied to diagnose trauma in cancer cases. The use of CT-Scan aircraft certainly provides a fairly large radiation dose compared to other diagnostic imaging modalities [1]. The radiation dose on a CT scan is very high because it gets a primary dose and a secondary dose once every scanning. The method of calculating patient amounts on a CT scan is known as the Computed Tomography Dose Index (CTDI).

The CTDI measurement of the phantom can be estimated as a dose measurement to the patient so that the CTDI measurement of the phantom surface can also be estimated against the CTDI received on the patient's body surface or the surface dose. The surface dose on the phantom can be measured on the top and bottom surfaces because the radiation source and detector from the CT scan machine rotate 360 [2] [3]. Monte Carlo software/programs can provide the closest approximation to individual patient dosimetry and are generally considered the "gold standard" among dosimetry techniques. However, today's patient-specific Monte Carlo techniques require high computational performance and highly specialized programming skills and are time-consuming [4].

2. METHOD

This type of research is quantitative with experimental, and this study varies the diameter of the phantom during the scanning process. The preliminary magnitude for the CT scan dose is CTDIvol. CTDIvol is a quantity to determine the importance of the aircraft output dose. The CTDIvol value is strongly influenced by exposure factors such as voltage (kV), tube current (mA), rotation time (s), pitch, collimation width, and specific values for each aircraft. The patient dose is calculated based on the magnitude of the CTDIvol with the patient's particular characteristics. The second quantity that describes the total energy transferred to the patient is the dose length product (DLP). This DLP is calculated based on the multiplication of CTDIvol and scan length (L). The patient's effective dose is usually calculated from this DLP and conversion factor (k). These CTDIvol and DLP values are usually displayed on the CT console screen on modern CT machines. These two values are also stored in the DICOM header for newer products. In addition, the CTDIvol and DLP values are quantities that must be checked periodically in the quality control (QC) program. In this IndoseCT software, there are three options to determine it: manual, calculation, and taken from the DICOM header. To calculate CTDIvol, select the CTDIvol button in the row of buttons. If the CTDIvol button is clicked, the color will change from white to cyan. By default, when this software is activated, what appears on the first screen is this CTDIvol calculation.

3. RESULTS AND DISCUSSION

Quantitatively, the data obtained during the scanning process are CTDIc, CTDIvol, and CTDIw. The CTDIc value indicates the magnitude of the CTDI value at the phantom center [5]. The CTDIw value approximates the average dose on a single slice [6]. CTDIvol represents the dose by volume scan of a specific scanning protocol for a standard phantom [7].

Table 1. Measurement Data For Ctdic, Ctdiw, And Ctdivol Using A Radiation Detector

No	Effective Diameter (cm)	Effective mAs	Normalized CTDIc	Normalized CTDIw	Normalized CTDIvol
1	8	14	25.90	39.53	46.51
2	16	24	23.31	35.57	39.44
3	24	51	10.61	16.20	19.06
4	32	120	5.83	8.90	10.47

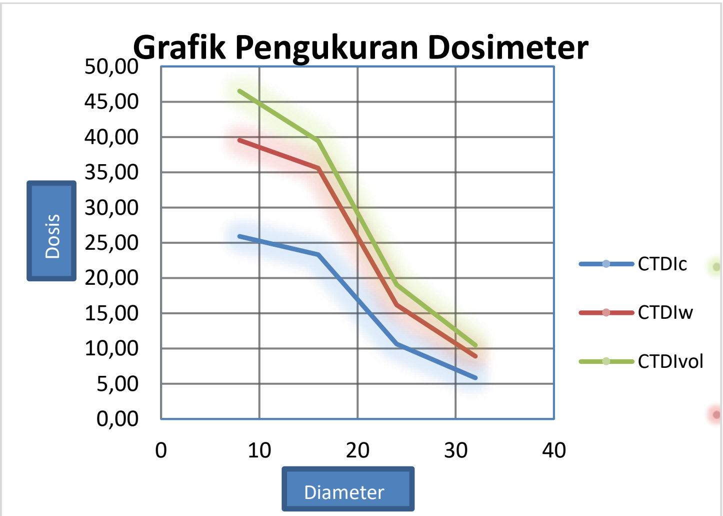

Figure 1. Graph Measurement of CTDIc, CTDIw, and CTDIvol

The CTDIc measurement data is shown in table 2. The CTDIc values form the same pattern as the Dicom image processed with IndoseCT, which can be seen in Figure 2. The graphic pattern obtained is the same because the dose measurement by the detector is carried out at the phantom center.

Table 2. CTDIc Measurement Value

No	Effective Diameter (cm)	Effective mAs	CTDIvol			Average	Normalized CTDIv	IndoseCT(mGy)
			Measurement 1	Measurement 2	Measurement 3			
1	8	14	7.352	7.448	4.733	6.51	46.51	44.24
2	16	24	9.614	9.435	9.351	9.47	39.44	36.43
3	24	51	9.578	9.592	9.985	9.72	19.06	9.22
4	32	120	13.03	12.8	11.87	12.57	10.47	9.96

The data obtained from the study also showed a change in tube current (mAs) in each CT Scan exposure. This change occurs because the CT Scan aircraft used for research uses the mAs auto setting. Auto setting mAs causes changes in the mAs value in each scan for different phantom diameter variations.

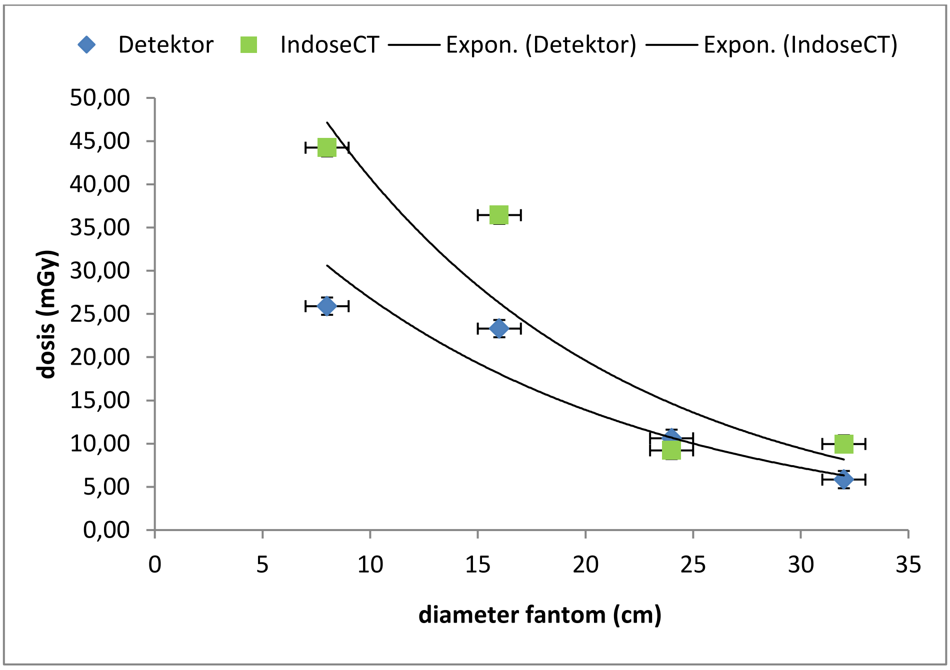

Figure 2. CTDIc Graph

The CTDIw measurement data are shown in table 3. The CTDIw value forms the same pattern as the Dicom image processed with IndoseCT, with the ends coincided, which can be seen in Figure 3. The dose calculation on CTDIw is based on the parameters of the body part, which are calculated automatically. In contrast, the dose calculation with IndoseCT uses conversion factors and calculation methods according to the standard AAPM report 204 to adjust the size of the phantom diameter [4].

Table 3. CTDIw Measurement Value

No	Effective Diameter (cm)	Effective mAs	CTDIvol			Average	Normalized CTDIv	IndoseCT(mGy)
			Measurement 1	Measurement 2	Measurement 3			
1	8	14	6.249	6.331	4.023	5.53	39.53	44.24
2	16	24	8.54	8.51	8.56	8.54	35.57	36.43
3	24	51	8.141	8.153	8.487	8.26	16.20	9.22
4	32	120	11.08	10.88	10.091	10.68	8.90	9.96

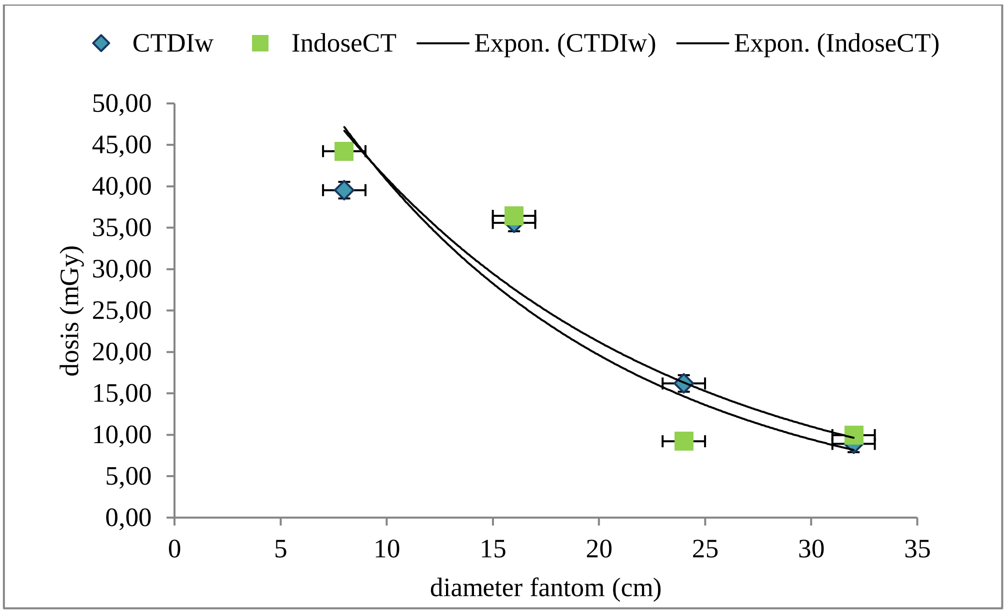

Figure 3. CTDIw Graph

Figure 3 shows the curve formed from direct detector measurements or with the IndoseCT program by processing the Dicom image coincided with phantoms measuring 8 cm, 16 cm, and 32 cm. The calculation of the CTDIw value by both the detector and the IndoseCT program shows almost the same value.

CTDIw is the calculation of the phantom center dose and the phantom edge dose. The dose value received by the phantom is represented by the dose detected by the piranha detector. Figure 3 shows the dose received by each phantom. The CTDIw graph shows that the radiation dose value is more significant in phantoms with smaller diameters. According to [8], the CT scan voltage affects the penetrating power of X-rays so that at a smaller phantom, more X-ray intensity is transmitted to the detector, resulting in a larger dose received by the detector[9].

Table 4. CTDIv Measurement Value

No	Effective Diameter (cm)	Effective mAs	CTDIvol			Average	Normalized CTDIv	IndoseCT(mGy)
			Measurement 1	Measurement 2	Measurement 3			
1	8	14	7.352	7.448	4.733	6.51	46.51	44.24

2	16	24	9.614	9.435	9.351	9.47	39.44	36.43
3	24	51	9.578	9.592	9.985	9.72	19.06	9.22
4	32	120	13.03	12.8	11.87	12.57	10.47	9.96

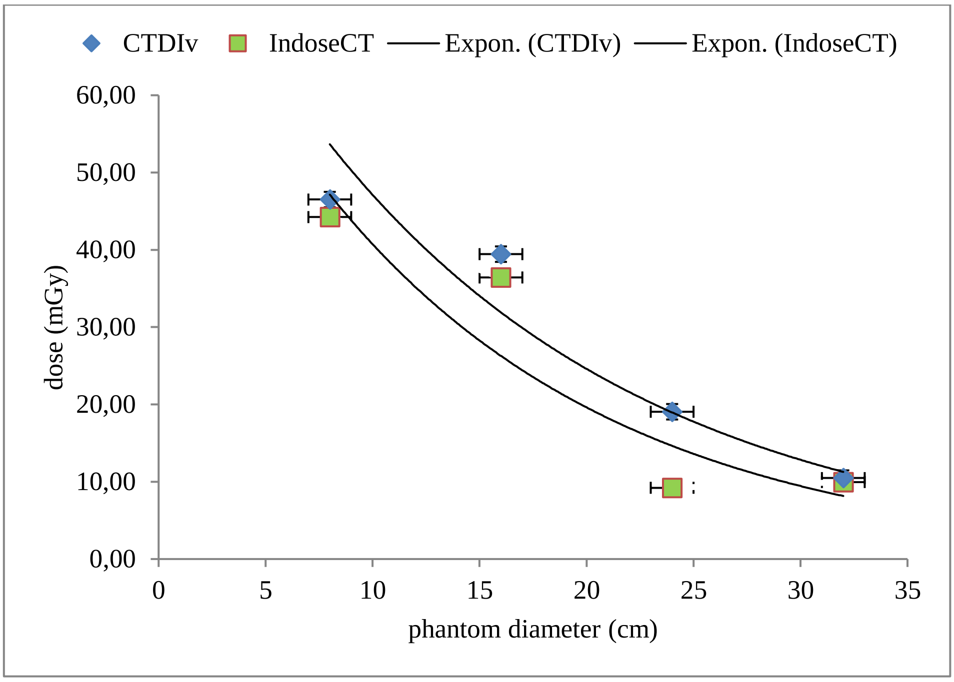

Figure 4. CTDIv Graph

Figure 4 is a CTDIv graph showing that the two curves coincide. The two coincidences show that the measurement of radiation dose with the piranha radiation detector and the calculation of the indoseCT program show almost the same results. CTDIvol is the volume of CTDI. In this study, only measurements were made at the center of the phantom so that the CTDIvol value obtained did not match the size of the small diameter phantom. Phantoms with small diameters (head size phantoms) should have CTDIvol values smaller than CTDIc [10].

4. CONCLUSION

The radiation dose on the CT Scan using IndoseCT calculations and measurements of the piranha detector decreased exponentially with the increase in the effective diameter of the phantom. The radiation dose measurement was carried out at the phantom center so that the CTDIvol value obtained did not match the size of the small diameter phantom. Estimation of radiation dose with image Dicom with IndoseCT program can show results with good accuracy. Create a phantom with materials that are closer to the actual body composition.

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