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CT Number Conformity Test on Multislice CT Scan at Yogyakarta PDHI Islamic Hospital

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ABSTRACT

This research focuses on determining the CT number, which is the attenuation coefficient value of x-rays after passing through an organ. The level of energy attenuation depends on the initial energy of the x-rays and the atomic number of the object, which play a role in describing differences in the characteristics of organs or body tissues. This research aims to ensure the suitability of the CT number to obtain accurate information about CT scan images. Research procedures include observation, data collection, and data processing. The CT number data from the experimental results was then compared with the simulation results using IndoQCT software. The CT Number conformity test is carried out on a water phantom by adjusting the tube voltage, input current, and slice thickness. The Region of Interest (ROI) is made in the form of a circle at five measurement points, namely the central direction, 3 o'clock, 6 o'clock, 9 o'clock, and 12 o'clock. The research results, both direct testing and simulation using IndoQCT software, show that the CT number does not exceed the accuracy tolerance limit and uniformity, respectively, $-4 < HU < +4$ and $-2 < HU < +2$. Based on the analysis results, it can be concluded that the CT number measurements in the Radiology Unit at the Yogyakarta PDHI Islamic Hospital meet the requirements of BAPETEN Perka Number 2 of 2018.

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1. INTRODUCTION

CT Scan is a process using digital processing to produce a three-dimensional internal image of an object or organ in the human body. Usually, digital images consist of pixels that form a two-dimensional image. However, in CT Scan the body image can be represented in three dimensions because it is produced from all the pixel pieces so that it can form a voxel image [1].

CT Scan was discovered in 1972 by an engineer named Godfrey Hounsfield from EMI London, England and a South African-born physicist named Allan Comack from Tufts University, Massachusetts. The first clinical presentation was held in 1972, which showed a scan image of a patient using a CT Scan, this marked the beginning of a new era in the development of diagnostic imaging. Since it was first discovered, CT Scan has undergone very significant developments, including developments in acquisition geometry, detector technology, and tube design. Currently, the development of CT Scan is leading to an increase in imaging speed with a multi-slice detector or Multislice Computed Tomography (MSCT) [2]. The advantages of MSCT are that it has a fairly short scanning speed and is able to show all human organs (whole body) in 3 dimensions with high resolution [3].

The working principle of CT Scan is that the x-ray tube rotates continuously by continuously emitting x-rays and the patient table will move linearly through the x-ray exposure area, and the intensity of the x-rays that have passed through the patient's body will be read by the detector. The data obtained will be converted into digital data (Numeric) to be entered into the computer, so that it will produce several image slices (slice thickness) in one rotation of the gantry [4]. CT Scan is a medical imaging device that involves radiation, so it can pose a risk if there is a failure in the x-ray generation and detection system. Therefore, it is necessary to carry out routine suitability tests to evaluate performance and ensure the safety of CT Scan. CT Scan suitability test according to BAPETEN Regulation Number 2 of 2018, consists of several parameters, namely voltage accuracy, radiation beam quality, patient radiation dose suitability, CT Number accuracy and uniformity, table position indicator, and laser marker.

CT Number is the attenuation value of x-rays passing through an organ, the size of the CT Number depends on the energy and atomic number. In addition, the CT Number is also influenced by the size of the ROI used to determine the number of pixels to be assessed. CT Number reflects the characteristics of each organ and body tissue. CT Number is measured in Hounsfield Units (HU). The accuracy of the CT Number calculation is important for accurate information, so that there are no diagnostic errors [5].

CT Number is in the range of values -1000 HU to +1000 HU. CT Number of -1000 HU represents air which will be shown with a darker colored image, while CT Number +1000 HU represents dense bone which is shown with a lighter colored image. While CT Number 0 which represents water will be displayed as the midpoint in the gray range [6] [7]. CT Number is obtained from the comparison between the tissue attenuation value and the water attenuation value, which is formulated in the following equation (1).

With the K value being the CT Number (HU) contrast scale factor constant with a value of 1000, μt indicating tissue attenuation and μw representing water attenuation. The CT Number suitability test on CT Scan was carried out on a water phantom. One type of water phantom is an acrylic cylindrical water phantom, which is a solid circular phantom composed of water, air and acrylic equivalent materials [8] Water phantoms generally have a diameter of 16 cm to simulate head CT, and a diameter of 32 cm to simulate adult body CT [9].

According to BAPETEN Regulation Number 2 of 2018, the CT Number tolerance limit is from the ROI at the center of the image is $-4 \leq CT \leq 4$, the maximum limit for the difference in CT Number from the ROI at the center of the image with the CT Number from the ROI at the edge of the image is $-2 \leq CT \leq 2$, the standard deviation value for CT Number is $\Delta SD \leq 2$ CT, and the linearity value of CT Number with the object's electron density is $R \leq 0.99$.

IndoQCT is a software used to evaluate CT image quality. IndoQCT is useful for facilitating Quality Control (QC) of parameters in CT image quality tests on various phantoms automatically. Some CT image quality test parameters are CT Number measurements (accuracy, uniformity, homogeneity, linearity), noise, slice thickness, low contrast, alignment. Distance measurements are divided into two, namely the distance for one slice (accuracy and distance of ROI to diameter) and the distance between slices, and are equipped with measurements for patient dose optimization or Computed Tomography Dose Index (CTDI). CTDI provides information in the form of an estimate of the average dose given for each examination [10]. So that IndoQCT is able to increase efficiency, measurement objectivity, universality, and reliability in the CT image evaluation process [11].

This study aims to ensure that there is no deviation in CT Number on CT Scan. The data obtained will be compared with the standards set by BAPETEN Regulation Number 2 of 2018 concerning the Suitability Test of Radiodiagnostic and Interventional X-Ray Machines. In addition, the suitability of the CT Number is also tested using IndoQCT software to ensure the safety and suitability of the CT Scan machine for patient examination.

2. METHODS

This study was conducted in the radiology unit of RSIY PDHI. The tool used in this study was a 16-slice CT Scan machine with the SIEMENS brand, type Somatom go.Now with serial number 107072 which has a maximum voltage of 130 KV and a current of 345 mAs, a SIEMENS brand water phantom with a diameter of 16 cm and a thickness of 9 cm as a test object. To reconstruct the image using a computer and console (Symo CT) and a dry imaging camera to print the image results on x-ray film. The CT Scan and water phantom images used in this study are shown in Figure 1 and Figure 2.

Figure 1. 16 slice CT Scanner SIEMENS brand type Somatom go.Now serial number 107072

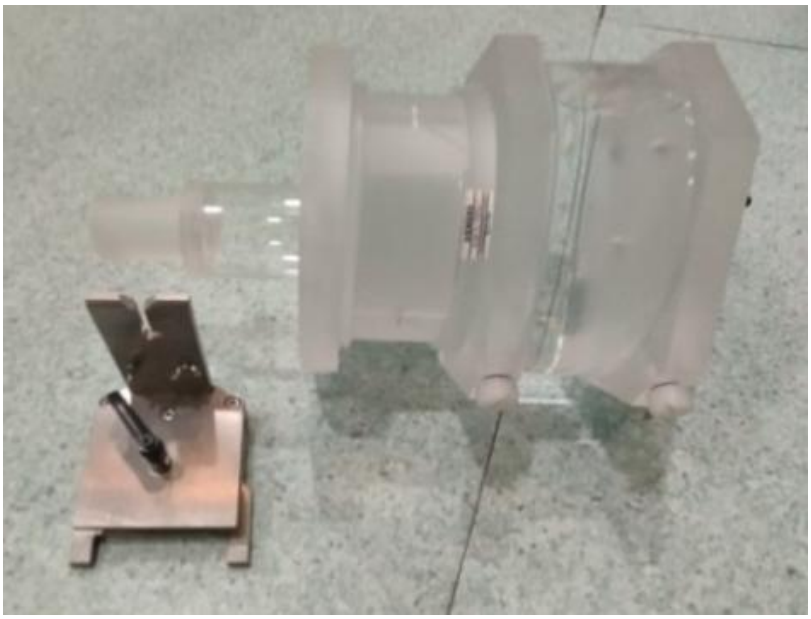

Figure 2. SIEMENS brand water phantom serial number 11061453

The research procedure for the CT Number suitability test on this multislice CT Scan can be seen in the flow diagram in Figure 3 below.

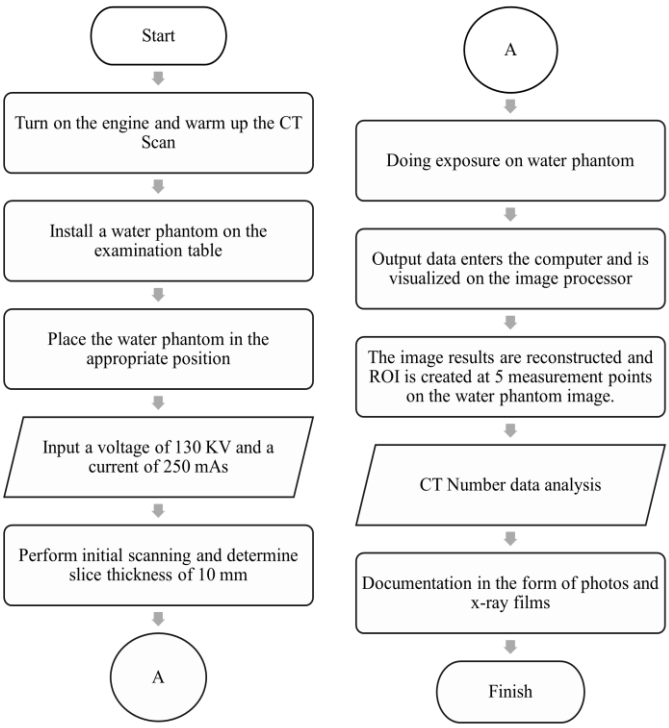

Figure 3. Research flow diagram

This study began by turning on and heating the CT Scan machine, then installing the water phantom on the examination table with the axial beam position right in the middle of the water phantom. The tube voltage was set at 130 KV and inputting a tube current of 250 mAs. The next stage was to perform an initial scan (topogram) on the water phantom to determine the boundaries of the area to be irradiated and determine the slice thickness of 10 mm. Scanning (exposure) was performed on the water phantom, then the scan data would enter the computer and be displayed on the monitor screen to be reconstructed with the SymoCT application.

For reading the accuracy and uniformity of the CT Number value, an ROI was created with an area of 1.85 cm2 at five CT Number measurement points, namely at the center of the image and the four edges of the water phantom image, namely at the 3 o'clock, 6 o'clock, 9 o'clock and 12 o'clock positions. After that, the CT Number data was analyzed and documented in the form of an x-ray film. An illustration of the placement of the ROI position on the water phantom image is shown in Figure 4 below.

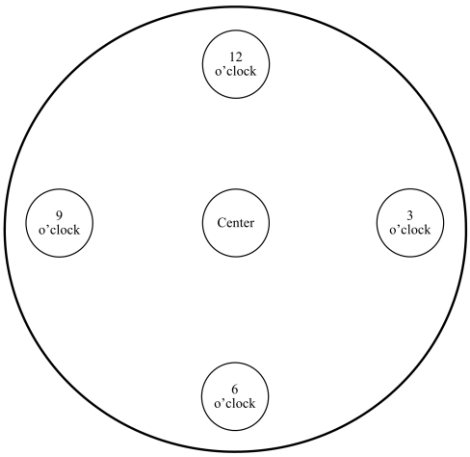

Figure 4. Illustration of ROI position on water phantom image

The CT Number test results are considered appropriate if they meet the standards in BAPETEN Regulation No. 2 of 2018, namely the central CT Number value does not exceed -4 to 4 HU and the CT Number uniformity value is within the limits of -2 to +2 HU [14]. In addition, the results of direct CT Number data collection will also be compared with the calculation of CT Number accuracy and uniformity using IndoQCT software.

3. RESULTS AND DISCUSSION

The results of the CT Number suitability test activities for the multislice CT Scan machine at the RSIY PDHI radiology unit are shown in Figure 5 and Table 1 below.

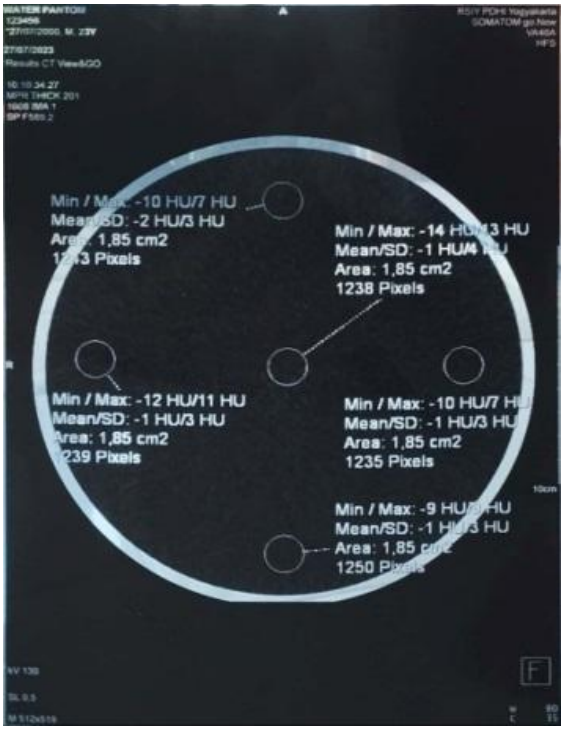

Figure 5. Print out results of CT Number testing

Table 1. CT Number values at 5 ROI positions for direct testing

ROI Position	CT Number	Difference with CT_{pusat}
Center	-1	
3 o'clock	-1	0
6 o'clock	-1	0
9 o'clock	-1	0
12 o'clock	-2	-1

Based on Table 1 above, the results of the CT Number test at the ROI position in the center, 3 o'clock, 6 o'clock, and 9 o'clock show the same value, which is -1, so there is no difference. While for the 12 o'clock direction, the CT Number value is -2, so there is a difference of -1 between the CT Number.

The CT Number suitability test is then compared with measurements using the IndoQCT software [15]. In testing using the IndoQCT software, the same parameters are applied as direct testing, namely using a water phantom with the same brand, namely Siemens, and measurements are taken at 5 ROI positions. In addition, the diameter in the IndoQCT software test is entered with a value of 53 px, where the value is equivalent to the ROI diameter in direct testing, which is 1.4 cm and an area of 1.85 cm2.

The accuracy and uniformity images of the CT Number with measurements using the IndoQCT software can be seen in Figure 6 and Figure 7, respectively.

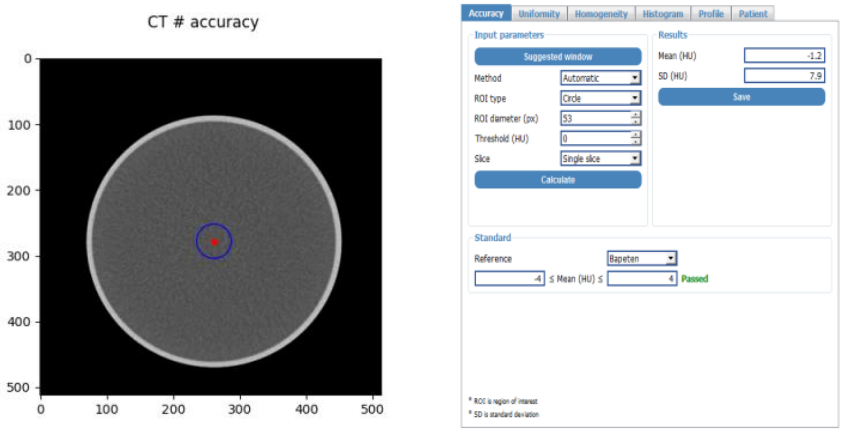

Figure 6. CT Number image and accuracy results from IndoQCT software
Print out results of CT Number testing

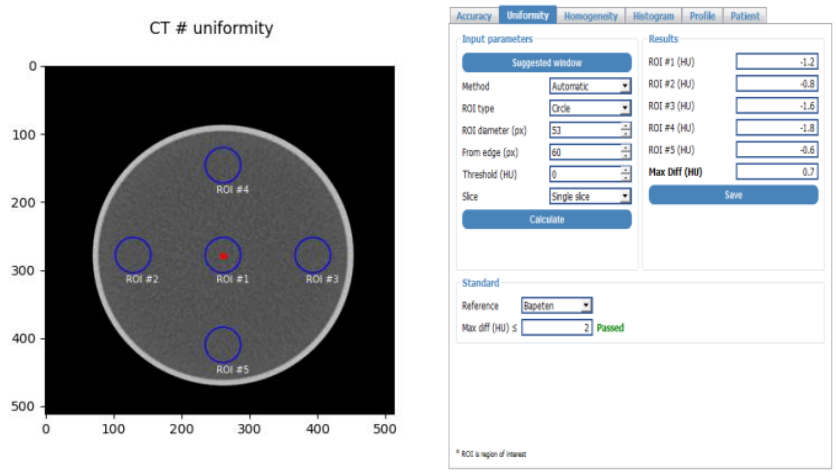

Figure 7. Image and CT Number uniformity results from calculations using IndoQCT software

The results of the Siemens CT Number phantom suitability test measured using IndoQCT software are shown in Table 2 below.

Table 2. CT Number values at 5 ROI measurement positions using IndoQCT software

ROI Position	CT Number	Difference with CT_{pusat}
Center	-1.2	
3 o'clock	-1.6	- 0.4
6 o'clock	-1.8	- 0.6
9 o'clock	-0.6	+ 0.6
12 o'clock	-0.8	+ 0.4

In the measurement results from both direct testing and using IndoQCT software, both have CT Number accuracy results that are still in accordance with the standard, namely in the range of -4 to 4 HU and the uniformity of the CT Number on the four edges of the image at the 3 o'clock, 6 o'clock, 9 o'clock and 12 o'clock positions obtained results that do not exceed the BAPETEN tolerance limit, namely -2 to 2 HU and the IAEA standard is ≤ 4 HU. The difference in the results of the two measurements is that there is a slight difference in the accuracy and uniformity of the CT Number, this difference in results occurs due to noise (interference), errors when inputting data into the IndoQCT software, or differences in image size on the phantom available

in the IndoQCT software with the water phantom used in direct testing. The difference in the results of these two measurements is considered not too significant because the values are still in accordance with BAPETEN and IAEA standards.

4. CONCLUSION

Based on the results of the CT Number suitability test that has been carried out directly, the central CT Number value is in the range of -4 to 4 HU, while the uniformity value between the central CT Number and the edge CT Number at the 3, 6, 9 and 12 o'clock positions obtained states that the value passes the test because it does not exceed the limit of -2 to 2 HU. In addition, after a comparison with calculations using the IndoQCT software, it also produces CT Number accuracy and uniformity values that are in accordance with BAPETEN and IAEA standards. So from the results of this test, it can be stated that the level of accuracy and uniformity of the CT Number on the Siemens brand CT Scan type Somatom go.Now 16 slices with serial number 230170960 in the RSIY radiology unit has passed the test and is still in accordance with the BAPETEN Regulation No. 2 of 2018, and is still suitable and safe to use for examination of patients.

DECLARATION

Author Contribution

A. R. Mas'uul, S. Indrawati, N. Handayani, contributed to the design and implementation of the research, to analysis of the results and to the writing of the manuscript.

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Conflict of Interest

The authors declare no conflict of interest.

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