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Quality Control of Multi-Slice CT-Scan Plane using Phantom Chart Model 610 at Makassar Haji Hospital

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ABSTRACT

This study aims to determine and analyze the quality control phantom chart of a CT-scan plane from the CT number's accuracy, the CT number's uniformity, and the uniformity of noise against the phantom. The AAPM CT Performance Phantom with the model 610 offers a single object to measure several different CT performance parameters. The Phantom design is based on the guidelines presented in the AAPM. From the measurement results, the accuracy of the CT number is still following the tolerance standard; namely, the value of passing the test ± 4 for the accuracy of the CT number, and the value of passing the test 2 is the uniformity of the CT number. Based on the Standard Regulations of the Head of the Nuclear Energy Supervisory Agency, stating that the value of accuracy and uniformity of the CT number from the CT scan image obtained in research conducted on a multi-slice CT scan plane at the Radiology Installation of the Makassar Haji Regional General Hospital shows the value of passing the test or still within PERKA BAPETEN standard.

Introduction

Medical imaging detects a disease due to physiological or pathological abnormalities [1]. The X-ray medical imaging modalities are computed tomography (CT), which can detect minimal differences in the x-ray absorption values represented in the axial, coronal, and sagittal or 3D planes [2]. CT image contrast is about ten times higher than conventional X-ray radiography. Due to its complexity, quality control of CT scanners must be

periodically carried out [16]. A particular phantom is usually used, such as the Ca-Phan, ACR, and AAPM CT performance phantom. The scanners' parameters include CT number linearity, spatial and contrast resolution, and slice thickness [3].

One of the critical parameters that must be measured in quality control is the accuracy of the CT number and its uniformity [4]. The CT number is the coefficient value of the x-rays carried by the average energy of the x-rays and the atomic number of the absorber. The role of the CT number in the CT-scan plane is to assess and distinguish abnormalities in human organs [5].

CT-scan is a means of supporting diagnosis that uses a combination of x-rays and a computer to obtain images or images in the form of variations of slices of the human body [6]. One type of radiation that is widely used in the field of radiodiagnostics is ionizing radiation [7]. This radiation is a type of radiation from x-ray devices used for various medical diagnostic needs such as x-ray scanners (roentgen) and other benefits. In addition to providing beneficial effects in its utilization, radiation also harms human health if you do not know the required dose limit value [8].

CT scanning uses the working principle of tomography, diagnostic imaging that uses an x-ray tube as a radiation source. A detector rotates around the object to obtain an axial image of the object [9]. Phantom has been widely applied in medical imaging, especially in CT systems, generally for image quality research quantitatively [10]. Many previous studies have highlighted the advantages of phantoms, especially when investigations involve multiple radiation exposures with different acquisition settings [11].

Quality checks are performed by evaluating phantom images, and the standard phantom is AAPM (America Association of Physicists in Medicine) [12]. Phantom standard from AAPM CT Phantom can perform CT number uniformity, cross-sectional thickness noise, linearity, spatial resolution, and contrast resolution with a single phantom enabling CT quality control [13].

Research on image quality is carried out to provide the correct information to ensure the CT scan results follow the requirements and make it easier for the medical team to read the CT scan results to avoid misdiagnosis [14]. With this background, the authors of this research are expected to know the accuracy of the CT number, the uniformity of the CT number, and noise [15].

Experimental Method

This research was conducted experimentally at the radiology installation of the Haji Makassar Hospital. Using a series of multi-slice CT scans with the GE Brivo 385 Type 46-274891G1 Brand and Phantom. The phantom used is the Phantom CIRS model 610.

Figure 1. CT Scan brand GE BRIVO 385

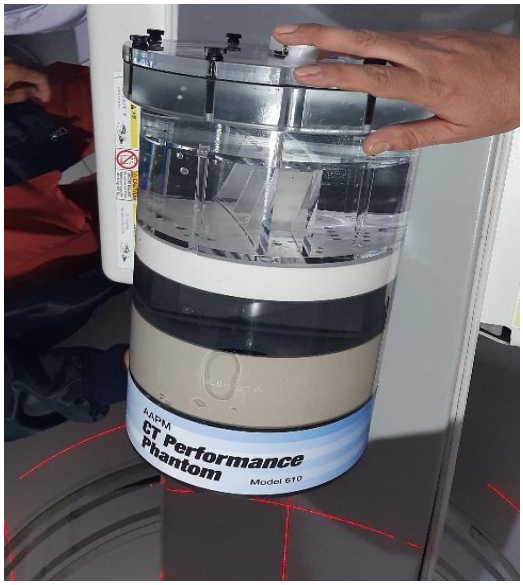

Figure 2. Phantom Model 610

The first stage of the research was to scan the phantom using the axial slice mode. Before the scanning process, the topogram of the phantom is carried out first to determine the area to be monitored. Image retrieval was carried out according to the examination protocol set by the hospital. The phantom is mounted at the end of the examination table, and inspection information will be obtained after scanning. Parameter settings used in the tube voltage is 120 kV and the time current on the tube is 125 mA. After the scanning process, the image is obtained in DICOM format, which will later be processed and analyzed using image processing software, namely Radiant DICOM Viewer, to carry out the ROI process. The ROI process is done by placing five different points on the image by creating an ellipse pattern. From the ROI process, the mean SD (standard deviation).

The CT number and uniformity aim to determine the average CT number in the water and its uniformity and, at the same time, choose the noise in the image. After the scan, the images obtained will be analyzed. By selecting the ROI at the center point (middle) and four others around the position, namely at edge 12, 3, 6, and 9. From the scan results, the value of the five ROIs is called the average CT number and uniformity. The standard value of the CT number in the middle of the phantom or the center of the deviation is ± 4 CT number from the value 0. Then for the CT number value in the edge 12, 3, 6, and 9 directions, the deviation is ± 2 from the CT number value in the middle.

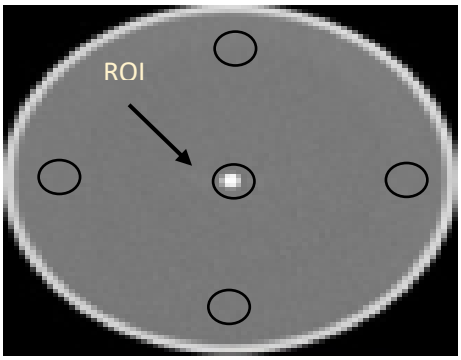

Figure 3. For the CT number uniformity test

Result and Discussion

The accuracy of the CT number value is very influential in determining organ density. It can significantly influence the diagnosis of a disease. This aims to assess the accuracy of the CT number value and how the uniformity of the CT scan aircraft is used.

The test was carried out using a water-filled phantom with a voltage of 120 kVp, a tube current of 125 mA, and a 5 mm slice width. Then to find out the value of the CT number, the Region Of Interest (ROI) is used, which is placed in the middle of the center and around the picture at the edge 12, 3, 6, and 9 positions. The value of the CT number and standard deviation can be seen in table 4.1. The test results are declared appropriate if the CT number value in the middle (central) position does not exceed the value of 4 CT numbers. Also, the CT number value at the position around the middle, namely at edge 12, 3, 6, and 9 positions, does not exceed 2 CT numbers from the middle position. As for noise, it is obtained from calculating the standard deviation value using the equation for the five positions of the CT number measurement. The noise value is allowed if the minimum value reduces the maximum noise value. The results obtained are less than equal to 2.

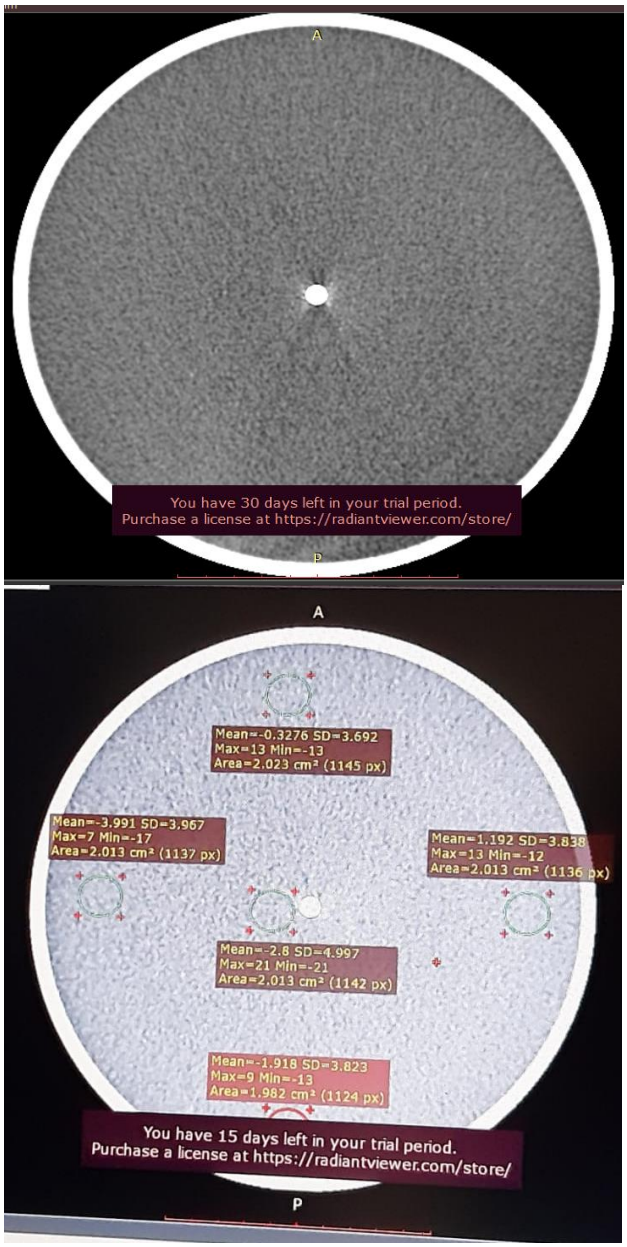

Figure 3. CT Number Image Results

The CT number test results were obtained from the CT number conformity test on a multi-slice CT-Scan appliance at the Radiology Installation of the Haji Makassar Regional General Hospital. The CT number accuracy value table results from the CT number value in the first slice using a phantom object with an accuracy value of -2.8 HU at the center of the image. The results obtained are still following BAPETEN regulatory standards. The value of the CT number uniformity test results on the slice of the CT number suitability test on a multi-slice CT-scan appliance at the Radiology Installation of the Makassar Haji Regional General Hospital, as shown in the following table.

Table 1. CT number uniformity value

ROI Position (edge)	CT Number	Test Passing Score
12	-0.3276	≤2
3	1.192	
6	-1.918	
9	-3.991	

The table above with the CT number uniformity value is the CT number measurement value where the value obtained at the edge 12 positions is -0.3276 HU. The edge 3 positions are 1.192, the edge 6 ROI position is -1.918, and the edge 9 is -3.991 HU. So that the overall value of the CT number on the CT scan aircraft is still following the standards used, then the value of the CT number accuracy obtained can be seen in the following table:

Table 2. CT number Accuracy Value

ROI Position	CT Number	Test Passing Score
Imaging axis	-2.8	±4

Based on the CT number accuracy value table, the following values are obtained with ROI placement at the center of the image. The value obtained is -2.8 HU, which means the value is still following the standard, namely -4 to 4 HU. The following is a table of values for the uniformity of noise obtained on a multi-slice CT-scan with the brand GE Brivo 385 Type 46-274891G1 at the Radiology Installation of the Haji Makassar General Hospital.

Table 3. Value of noise uniformity

ROI Position (edge)	Noise	Noise uniformity standard parameter	Test Passing Score
12	3.692	0.14	≤2
3	3.838		
6	3.823		
9	3.967		

The CT number value explains that the X-ray attenuation coefficient in each edge area is similar. The uniformity of the resulting image will be better. Then it can be ascertained that the response is still good. The dose received by the patient is evenly distributed so that it can impact the quality of the reconstructed image that has good contrast, sharpness, detail, and density. Based on the standard regulations of the head of the nuclear energy supervisory agency, states that the accuracy and uniformity of the CT

number from the CT-scan image obtained in research conducted on a multi-slice CT-scan appliance at the Radiology Installation of the Makassar Haji Regional General Hospital shows the value of passing the test or is still within PERKA BAPETEN standard.

Conclusion

The tests have obtained the CT number value for the water phantom at five different positions, which are in the tolerance value range of -4 to 4 HU. The results of the CT number readings on the multi-slice CT scan of the Radiology Unit of the Makassar Haji Regional General Hospital, which were processed using two methods, namely the calculation method and the radiant software method, resulted in the conclusion that it was stated that the accuracy and uniformity of the CT number still matched the tolerance standard from BAPETEN

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