International Journal of Advanced Biotechnology and Research (IJBR)
ISSN 0976-2612, Online ISSN 2278–599X,
Vol-9, Issue-1, 2018, pp165-170
http://www.bipublication.com

Research Article

Assessment of water CT number, field uniformity and noise in diagnostics computed tomography scanners in Urmia metropolis, Iran

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ABSTRACT

Since the dose received by patients should be minimized in computed tomography scan, the quality control of the scanners is one of the main concerns. For this reason, quality control tests (water CT number, field uniformity and noise) should be carried out regularly.The design used for this study was descriptive and cross-sectional. One private radio-diagnostic center (A) and one government hospital (B) were selected for this study. Two CT scanners were tested in the selected centers, one from center A, and one from center B. The phantoms used for the experiments were head CT water phantom and we chose one ROI in the center of the image and four ROI's at the periphery of the image, then we recorded the mean values of the CT number and standard deviation that reported by the system for these ROIs.Philips 64 slices scanner in center A has passed CT number for water, field uniformity and noise tests because the values are within the acceptable limit and the Siemens 6 slices scanner has passed CT number for water, field uniformity tests but don't pass noise test because the measured values are out of the acceptable limit.CT scanners in Urmia have passed the CT number for water and field uniformity tests, but the Siemens 6 slices scanner doesn't pass the standard deviation test.

Keywords:CT; Quality Management; Water CT Number; Field Uniformity; Noise

INTRODUCTION

According to statistics released in 2009, 70 million CT scans are taken annually in the united states(1). Cross-sectional images that created by computed tomography (CT) scanners have high radiography contrast. CT images have vastly superior contrast than that obtained from radiography images, for this reason, the CT images used for diagnosis of soft tissue. Although CT scans have great medical benefits, So there is concern about the possibility of future cancer, because their produced radiation dose is relatively higher than conventional radiography.(2). In addition to diagnostic applications, CT scanners are used in radiotherapy departments for image acquisition for treatment planning purposes. So, for the best treatment, CT scanners should be controlled in terms of quality(3).

Poor equipment situation and poor optimization of radiography scanner might be caused to patients received a high radiation dose. Primarily concern to quality control tests of the CT scanners was keeping the CT scanner at the optimized utilizable situation for providing the necessary diagnostic information at the least conceivable exposure to ionizing radiation. The responsibility of daily quality control of CT number of water, field uniformity and noise in each imaging center is with the radiographer(4).

To ensure equipment producer characteristics for CT number, and that the CT number that the scanner shows is accurate and all relative calibrations of all water-based CT numbers are within acceptable limits water CT number test and field uniformity is performed.

When CT scanner is used for quantitative assessment of CT values, exclusively for radiotherapy, the uniformity of CT number becomes very important(5). To determine the accuracy of the reconstruction process, the field uniformity test is performed by evaluating the CT number for water and uniformity of the CT numbers obtained by scanning a uniform water phantom. Miss-calibration of the algorithm producing CT numbers is the conceivable reasons for the CT number to be out of acceptable range and needs urgent attention of the radiation safety officer or biomedical engineer(6). This type of difficulty can cause to miss-interpretation of the CT images(7).

Percentage of image contrast in CT numbers can be defined as the noise level in CT. In other words, fluctuations in the CT numbers around its average value in a uniform medium express the noise. The following factors can be the main reason of noise in CT images: matrix size, number of detected photons, slice thickness, algorithm, object size, electronic noise, and scattered radiation.Noise confines the low contrast resolution and caused the diagnosis of pathology or anatomy similar to the surrounding tissue to be harder(6).

Medical physicist or an engineer will correct any discrepancy that revealed by the radiographer's daily check of the mentioned tests. The aims of this study are evaluating thementioned tests for diagnostic CT scanners in Urmia metropolis.

METHODS AND MATERIALS:

The design used for this study was descriptive and cross-sectional. The sampling method used to select two centers was purposive. One private radio-diagnostic center and one government hospital were selected for this study. The private radio-diagnostic center was named as center A and the government hospital was named as B.Two CT scanners were tested in the selected centers, one from center A, and one from center B. In each center, before the start of the test, we asked about the availability of the records of images of the QC tests being conducted on the installation of the equipment and the subsequent daily QC tests being conducted on the scanners.The machine at center A is Siemens 6 slices scanner made in the Germany and at center B is Philips 64 slices that made in the Netherlands.All of the instructions used in this study are based on quality control manual that released by ACR in 2012(8).

The phantom used for this study is the CT water phantom that provided by machine manufacturer at the time of the scanner installation for the purposes of quality control tests. The same phantom and manufacturer's guidelines provided in the manual for QC tests were strictly followed to conduct the procedures to check the CT number for water, field uniformity and noise(figure1,2). The head water phantom used for the tests, therefore, brain protocol was used to scan the phantom. The phantom was placed on the tabletop with the aid of phantom holder. The phantom was then aligned such that it was at the center of the gantry in the axial, sagittal and coronal planes.The CT internal or external alignment lights or laser accurately positioned over the center portion of the water phantom. Finally, the coronal light to up/down the center of the phantom, the axial light was aligned to the center of the phantom and the sagittal light to the left and right of the phantom(9).

The head technique which is most frequently used, applied to scan of phantom and 5 mm slice centers. Mean CT number and standard deviation were then measured using the obtained images. Table 1 indicates the parameters used in each center. To determine the CT number of water, field uniformity and noise we scanned the image thickness was used in center A and 10 mm slice thickness was used in center B. In center A slice thickness more than 5 mm was not possible. In center A 120KVp and 350 mAs and in center B 110KVp and 100 mAs was used to scan the phantom.We wanted to apply the same exposure conditions in both centers, but due to system constraints, this requirement was not possible. Regions of interest of about 5 cm^2 were selected for images obtained in both

and four ROI's at the periphery of the image, then we recorded the mean values of the CT number and standard deviation that reported by the system for these ROIs.

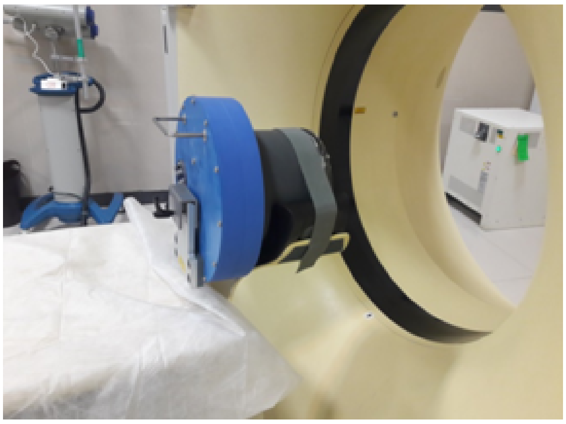

Figure 1. Phantom used in center A

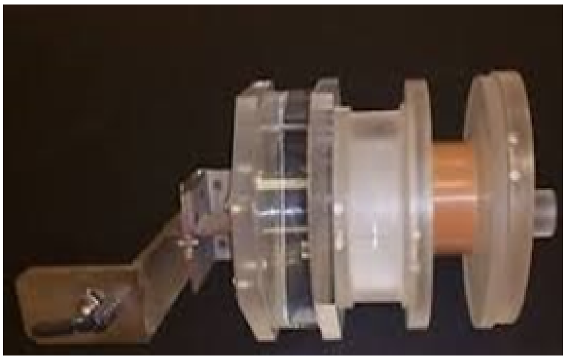

Figure 2. Phantom used in center B

Table1. scan parameters used in alignment of phantom in brain protocol

Scanner	Kvp	mAs	Rotation time(s)	Slice thickness(mm)
Philips 64 slices	120	350	1	5
Siemens 6 slices	110	100	0.6	10

RESULTS

The results of the quality control experiments we conducted are as follows(figure 3,4). In the below tables, the column 5 is related to center ROI andcolumns 1,2,3,4 respectively, related to upper, down, left and right ROIs(table 2,3).

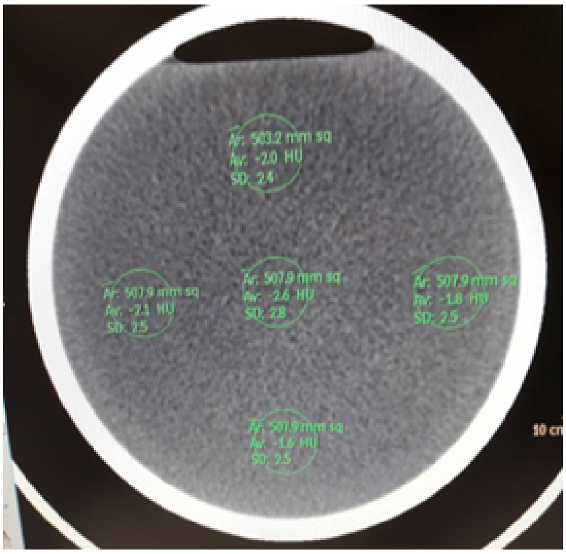

Figure 3. Field uniformity obtained from water phantomscan by Philips 64 slices scanner

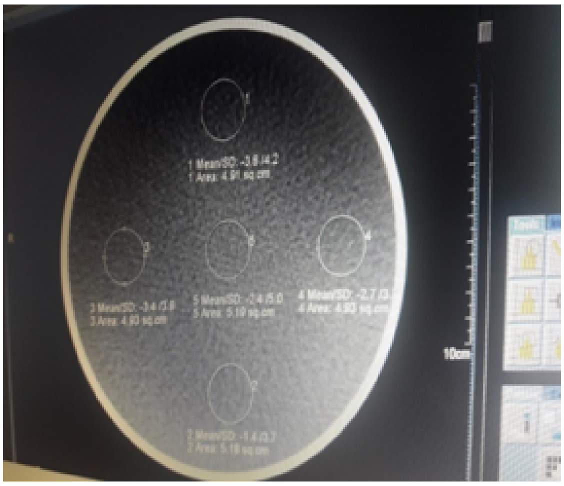

Figure 4. Field uniformity obtained from water phantom scan with Siemens 6 slices scanner

Table2. Values for mean CT number for water andstandard deviation for 5 ROI in center A

Region of interest	1	2	3	4	5
Mean CT number	2.0	1.6	2.1	1.8	2.6
Standarddeviation	2.4	2.5	2.5	2.5	2.8

Table3. Values for mean CT number for water andstandard deviation for 5 ROI in center B

Region of interest	1	2	3	4	5
Mean CT number	3.8	1.4	3.4	2.7	2.4
Standarddeviation	4.2	3.7	3.9	3.7	5.0

DISCUSSION

The CT numbers for water and field uniformity checked by the performed tests was the same as checking the reconstruction algorithm that computes CT numbers across the images. According to the standard instructions given by the manufacturers of CT machines, the CT number of water is equal to zero and the range of +/-3 in the center of an image and the range of +/-5 in the peripheral regions are acceptable.The standard for field uniformity is that the measured number in the center ROI should be less than 3 HU and for the 4 selected ROI in peripheral it should be in the range of +/- 5 HU acceptable in the center. The results of this study show that Philips 64 slices scanner in center A and Siemens 6 slices scanner have passed CT number for water and field uniformity tests because the values are within the acceptable limit.

This is a sign that the reconstruction algorithm that computes the CT number of the images is working correctly, therefore, good quality diagnostic images with low radiation dose are expected from the scanner.The noise level in CT images can be expressed as a percentage of image contrast in CT numbers. The standard deviation for noise should be +/-3. The maximum standard deviation between the center ROI and any peripheral ROI is less than +/-5 HU. The Philips 64 slices scanner passed noise test because the measured values are within the acceptable limit, But the Siemens 6 slices scanner don’t pass noise test because the measured values are out of the acceptable limit andthis can compromise the quality of the images produced by the scanner which might lead to the wrong diagnosis.

The possible causes of noise in CT images are; matrix size (pixel size), algorithm, scattered radiation, number of detected photons, slice thickness, electronic noise (detector electronics), and object size. The important tip is that noise reduces low contrast resolution and may hide anatomy similar to surrounding tissue. Most pathologies imaged in CT is seen in soft tissues such as the liver, lungs, brain and kidney and this can lead to miss interpretation of the CT images.

According to the brain scan protocol, we should use 280-300mA and 120KVp but which was not possible due to device constraints, these parameters can also affect the level of noise.

CONCLUSION

CT scanners in Urmia have passed the CT number for water and field uniformity tests, but the Siemens 6 slices scanner doesn’t pass the standard deviation test. One way should be to ensure that the images that produced by scanners have high quality and The patient's dose is within acceptable limits. Excessive noise can make the interpretation of images harder and may be confused, so it is recommended that a smooth reconstruction algorithm be used. Based on the study, the following recommendations are made:

1. Qualitative control tests should be carried out on a regular basis.
2. In case of observing the problem, inform the responsible.
3. Images of the QC tests should be kept in record.

This is the first study carried out in Iran, so we recommended these image quality tests for CT must be performed in other Iranian centers.

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