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Evaluation of Some Quality Control Parameters in Diagnostics Computed Tomography Scanners in Kano Metropolis, Nigeria

KEYWORDS: Quality control tests, computed tomography scanners and Kano metropolis

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ABSTRACT *Background: Quality control tests for computed tomography (CT) scanners are primarily concerned with the maintenance of CT scanner at the optimum operational condition.*

Aims of the study: The study aims at evaluating the CT number for water, field uniformity and noise for diagnostics CT scanners in Kano metropolis.

Methods and Materials: Cross-sectional design was employed in the study. Using purposive sampling technique two centres were selected, one government hospital and one private radio-diagnostics centre. The phantoms used for the experiments were head CT water phantom and regions of interest were measured at centre of the image of the scan phantom and four other regions at the periphery of the images.

Results: The mean CT number for water for Toshiba 162 slices was found to be 1.7 and standard deviation of 7.2, for GE 4 slices scanner was 0.1 and standard deviation of 2.28. Mean CT number for GE 16 slices scanners was found to be 1.58 and standard deviation of 9.77.

Conclusion: Computed tomography scanners in Kano metropolis complied with standard CT number for water and field uniformity but revealed high failure of noise tests.

Introduction

Computed tomography (CT) scanners create cross-sectional images of the human body with a high radiographic contrast. This is mainly significant for diagnosis of pathological conditions involving soft tissue. The imaging modality is progressively becoming the modality of choice for a rising number of radiological investigations, because the contrast of the images acquired is greatly superior to that obtained from normal conventional radiography. The drawback of this modality is high radiation dose to the patient when compared with normal conventional radiography. The high radiation dose to patient might be due to poor optimization of scanner radiographic protocols and poor equipment condition. Computed tomography scanners are under rapid technological development, resulting in increasing clinical applications, which in turn highlights the need for continual professional education. The increasing complexity of scanner operation and application requires careful monitoring to ensure that procedures are optimize for diagnostic image quality and patient dose. To achieve this, it is essential to promote and facilitate the implementation of a quality assurance (QA) program[1].

Quality control tests for CT scanners are primarily concerned with the maintenance of CT scanner at the optimum operational condition for providing the required diagnostic information at the least possible exposure to ionizing radiation[2]. The CT number for water, field uniformity and image noise are daily quality control tests that are within the limits of radiographer. The tests are conducted using the same CT water phantom provided by the equipment manufacturer during the instillation of the equipment. The CT number for water test and field uniformity is done to ensure equipment manufacturer specifications for CT number. Therefore, when we check the CT number for water and field uniformity we are effectively checking the reconstruction algorithm that computes CT numbers across the image. Possible causes for the CT number of water to be out of range is miss-calibration of the algorithm generating CT numbers and needs immediate attention of the biomedical engineer or radiation safety officer[3]. This kind of problem can lead to miss-interpretation of the CT images[4]. The noise level in CT can be stated as a percentage of image contrast in CT numbers. Noise in CT images is mainly related to: number of detected photons, matrix size (pixel size), slice thickness, algorism, electronic noise (detector electronics), scattered radiation and object size. Noise limits low contrast resolution and may hide anatomy or pathology similar to surrounding tissue[3]. Daily check of CT number for water, field uniformity and noise by radiographer could revealed any discrepancy or inconsistency on the equipment which could be corrected either by Medical Physicist or an Engineer to ensured that the images produced are of high diagnostic quality. The study aims at evaluating the CT number for water, field uniformity and noise for diagnostic CT scanners in Kano metropolis.

Methods and Materials

Descriptive and cross-sectional design was employed in the study. Purposive sampling method was used to select two centers; one government hospitals and one private radio-diagnostic centre. There are four centers with functioning CT scanners but only two agreed to participate in the study. The government hospital was named as centre A and the private radio-diagnostics centre was named as center B. Three CT scanners were tested in the selected centers, two from centre A, and one from centre B. One of the machines at A is Toshiba 162 slices scanner; the second one is GE 4 slices scanner. Both private radio-diagnostics centre B has GE 16 slices CT scanner. In each centre before the commencement of the experiment we asked of the availability of the records of images of the QC tests being conducted on the instillation of the equipment and the subsequent daily QC tests being conducted on the scanners. CT water phantom provided by the manufacturer of each machine at the time of the scanner installation for the purposes of quality control tests was used to conduct

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the experiments, CT number for water; field uniformity and noise were tested using the same phantom[5]. The manufacturer's guidelines provided in the manual for QC tests was strictly followed to conduct the procedures.

The phantoms used for the experiments were head phantom which is 25cm in diameter therefore brain protocol was used to scan the phantom. With the aid of phantom holder, the phantom was placed on the tabletop, if not available, the phantom was place carefully on the tabletop and secured with a radiolucent flexible tape. The phantom was then aligned such that it was at the center of the gantry in the axial, sagittal and coronal planes. The CT external or internal alignment laser or lights were accurately position over the center portion of the water phantom. Finally the axial light was aligned to the center of the phantom, the coronal light to up/down center of the phantom and the sagittal light to left and right of the phantom[5].

The phantom was then scan with head technique which is most frequently used, 2.5 cm slice thickness was used in all the phantoms. In centre A 120KVp and 225mA was used for Toshiba scanner and 120KVp, 298mA was used for GE. In centre B 100KVp and 100mA was used to scanned the phantom. We intended using the same exposure parameters in all the selected centers but the radiographer's in-charge of centre B said that they don't go beyond 100mA and 100KVp because of power supply. Regions of interest of about 2-3cm or containing 200-300 pixels were selected for images obtained in centre A. While in B regions of interest of 1.6 cm or 180 pixels were selected. Mean CT number and standard deviation were then measured using the obtained fist images.

Results
In the entire study area none of the radiographer in-charge of the scanners shows the availability of images of QC tests on installation of the equipment or the images of the subsequent daily QC tests images.

Table 1: Values for mean CT number for water and standard deviation for 5 ROI in centre A

Region of interest	1	2	3	4	5
Mean CT number	1.7	2.2	2.2	2.3	3.4
Standard deviation	7.2	7.3	6.2	7.3	6.3

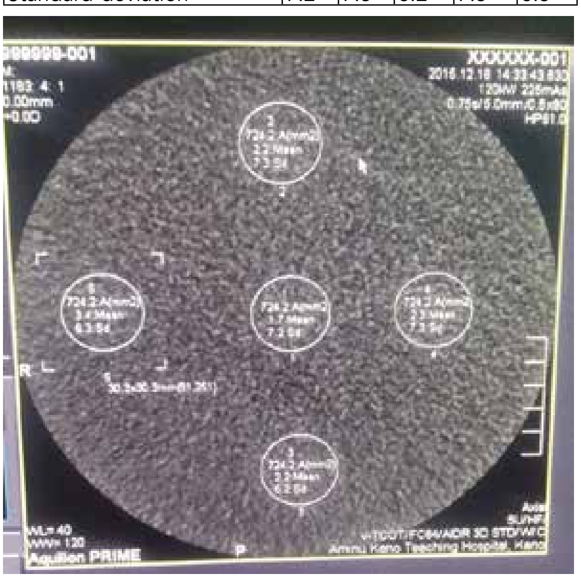

Figure 1: Field uniformity obtained from water phantom scan by Toshiba 162 slices scanner

Table 2: Mean CT number and standard deviation for 5 ROI in centre A

Regions of interest	1	2	3	4	5
Mean CT number	0.84	0.67	1.16	1.00	1.14
Standard deviation	0.22	2.11	2.22	2.32	2.16

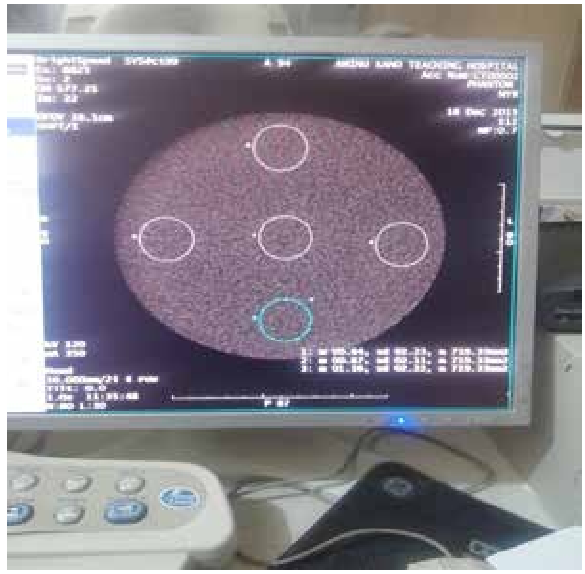

Figure 2: Field uniformity obtained from water phantom scan with GE 4 slices scanner

Table 3: Values for mean CT number and field uniformity for three regions of interest in centre B.

Region of interest	1	2	3
Mean CT number	2.80	2.35	3.51
Standard deviation	8.70	8.93	9.47

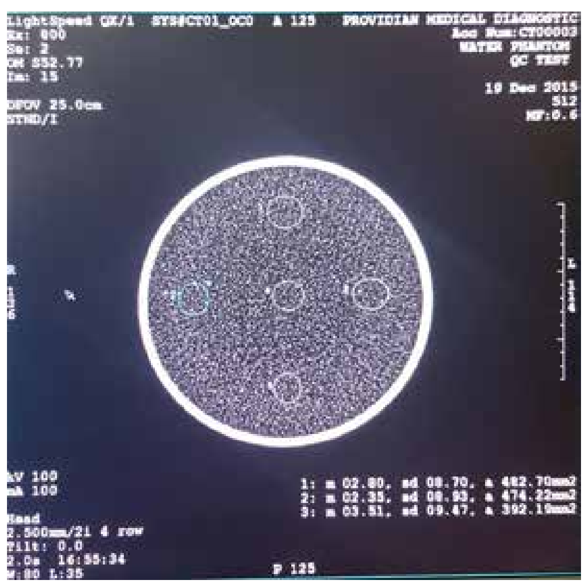

Figure 3: Field uniformity obtained from water phantom scan with GE 16 slices scanner

Discussion
The CT numbers for water and field uniformity checked on the experiments above was the same as checking the reconstruction algorithm that compute CT numbers across the images. According to standards guidelines provided by

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the manufacturers CT number of water equal to zero, but range of +/- 3 at center of image is acceptable, and +/- 5 HU at peripheral locations. The standard for field uniformity center ROI measured < 3 HU and the four ROI's in the periphery measured within the acceptable < +/- 5 HU of center measurement. The noise level in CT images can be stated as a percentage of image contrast in CT numbers. The standard deviation for noise should be +/- 3. Since CT numbers range from +/-1000 HU, noise is less than 0.3%. The maximum standard deviation between the center ROI and any peripheral ROI is less than +/- 5 HU.

The findings of the study show that Toshiba 162 slices scanner in centre A has passed CT number for water and field uniformity tests because the values are within the acceptable limit. This is an indication that the reconstruction algorithm that compute the CT number of the images is working perfectly. But the scanner failed noise test because the value is far above the acceptable limit. The possible causes of noise in CT images are; number of detected photons, matrix size (pixel size), slice thickness, algorithm, electronic noise (detector electronics), and scattered radiation and object size. The implication is that noise limits low contrast resolution and may hide anatomy similar to surrounding tissue. Most pathology imaged in CT is seen in soft tissues such as the lungs, kidney, liver, and brain and this can lead to miss-interpretation of the CT images. The GE 4 slices scanner in centre A has passed CT number for water, field uniformity and noise tests because the values are within the acceptable limits therefore good quality diagnostic images with low radiation dose are expected from the scanner.

The 16 slices GE scanner in centre B has passed the CT number for water and field uniformity tests, the values are within the acceptable limit. But it failed the noise test because the value is far above the acceptable limit. This can compromised the quality of the images produced by the scanner which might lead to wrong diagnosis and this agreed with the study conducted by Nicholas *et* al[3] on Quality Assurance and Helical Scanner which shows that the scanner tested had passed the CT number for water and field uniformity tests. But it went contrary to this study because it also passed the noise test. The study is also in accordance with the study conducted by Jessica *et* al[6] on evaluation of over 100 scanner-years of computed tomography daily quality control data which shows that standard deviation (noise) of water yielded the highest failure rate and, mean water CT number and uniformity and linearity have relatively low failure rates. Another study conducted by Diana *et* al[7] on quality control and dosimetry in computed tomography units agreed with this study. The results of their study indicated compliant with the standards of quality control tests in two units with non-compliant in one unit. One of the limitations to the study encountered was that instead of measuring 200-300 pixels, 180 pixels centre B and this might affects the results of the experiment. Another challenged faced in the centers was the exposure parameters, 100mA and 100KVp were used instead of 280-300mA and 120KVp for brain protocol and exposure parameters have an effect on image quality, this might affect the level of noise in image. Fewer number of CT scanners was also limitation to the study. Further studies should include all the quality control tests for CT that are within the limits of radiographers as stipulated by the International standards.

Conclusion

Diagnostic CT scanners in Kano metropolis have passed the CT number for water and field uniformity tests but revealed highest failure of standard deviation tests. A facility should ensure that scanner operates at the acceptable level of performance as this will produce the highest image quality and the most appropriate dose performance. Based on the findings of the current study the following recommendations were made;

1. Facility should ensure that QA programme is fully implemented
2. The scanners that failed the test engineers should be invited for corrective actions
3. Images of the QC tests should be kept in record

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