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Original Research Article

Rotation Time and Dose Reduction in Chest CT scans

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Abstract: Computed tomography is associated with exposing patients with high radiation doses. This study was conducted to evaluate the effect of reducing the rotation time to reduce the dose without compromising the image quality. Two types of CT scanners were involved in this study: a 4-slice and a 16-slice scanner. A significant reduction in CTD Ivol and DLP were observed with the 4-slice scanner, with a considerably low increase in noise.
Keywords: Computed tomography, CTD Ivol

INTRODUCTION

Computed Tomography (CT) was introduced into clinical practice in 1972 and revolutionized x-ray imaging by providing high quality images, which reproduced transverse cross sections of the body. The simultaneous introduction in 1998 of computed tomography with multislice acquisition and half-second rotation times allowed major advances in CT imaging.

Multislice CT (MSCT) with sub-second rotation times allows for the scanning of long ranges (advantageous in, for example, peripheral multislice CTA), for shorter scan times (advantageous in, for example, pediatric CT and trauma), and for a reduction in movement artifacts (as, for example, in ECG gated cardiac CT). With the reconstructed thin axial sections provided by MSCT, a near-isotropic 3-dimensional volume with sub-millimeter sized voxel can be constructed, that is well-suited for review on advanced 3D workstations. This is particularly true for 16 (or more) slice scanners [1].

16-slice CT allows applications of three-dimensional (3D) images in clinical fields such as diagnosis, surgical simulation, planning of radiation therapy and monitoring of interventional therapy [2]. Because of its geometry and usage, CT is a unique modality and therefore has its own set of specific parameters for radiation dose [3]. CT-scanners are becoming more and more popular imaging modality amongst medical practitioners as their tools for diagnostic practices. Continuing advances in CT technology coincide with increasing utilization of CT as diagnostic tools. However, CT is associated with relatively high radiation doses; with a corresponding increased risk of carcinogenesis [4]. The high radiation dose from CT procedures has increase the concern regarding the associated radiogenic risk. Unlike conventional radiography, CT exposes patients to higher radiation doses than do conventional diagnostic x-rays. For example, a chest CT scan (8 mSv) typically delivers more than 400 times the radiation dose of a routine chest X rays (0.02 mSv) [5, 6]. It had been estimated that CT radiation doses generate 0.7% of total expected cancer prevalence and 1% of total cancer death [7].

Image acquisition factors affect patient doses include tube voltage, tube current; scan length and imaging technique (helical or sequential). However, the wide variation in patient doses can be minimized if proper exposure factors were selected, and patients will exposed to radiation to justifiable radiation doses consistent with the diagnostic purposes [8].

Chest CT are commonly used to detect various disorders such as abnormalities and disorders of the lung found on conventional chest x-rays or ultrasound, help diagnose the causes of clinical signs or symptoms of disease of the chest, such as cough, shortness of breath, chest pain, or fever. It is also used to detect and evaluate the extent of tumors that arise in the chest, or tumors that have spread there from other parts of the body. And to evaluate the progress of disease and effects of therapy [9].

MATERIALS AND METHODS

Two detectors were used in this study: a 4-slice and a 16-slice CT scanner by Siemens. A total of 60 patients undergoing chest CT at Alneilain diagnostic center were included in this study. Routine image acquisition was performed using AEC settings. Using AEC dose can increase or decrease depending on reference image quality setting at the time of installation. The patients were divided into two groups: one before rotation time reduction and the other afterwards. The following parameters were entered: kV, (tube current), gender, height, weight. Patient doses were determined by using the CTD Ivol expressed in mGy and the DLP in mGy.cm as provided on the scanner console. These values were very valuable for statistical purposes, as they might possibly allow for analysis of scanner dependency. The collection of patient exposure parameters was done using patient dose data sheet. The rotation time was altered from 1 second to 0.7 seconds for the 4-slice detector and from 0.7 seconds to 0.5 seconds for the 16-slice detector. The effects on the dose and image quality were assessed. Three consultant radiologists evaluated all the medical images. Patients with gross pathology or studies that required special scanning parameters for any reason were excluded.

RESULTS

Table 1 below shows the comparison of CTD Ivol before and after reduction of rotation time. Table 2 below shows the comparison of DLP before and after reduction of rotation time. Table 3 below shows the comparison of noise expressed in SD before and after reduction of rotation time.

Table 1: CTDIvol comparisons

Detector	Before time reduction	After time reduction	Reduction %
4-slice	20.60±6.3 (11.7-15.6)	14.60±1.7 (11-15)	34.1%
16-slice	4.67±1.3 (2.6-7.3)	4.40±1.4 (1.9-6.8)	5.9%

Table 2: DLP comparisons

Detector	Before time reduction	After time reduction	Reduction %
4-slice	651.8±133.2 (463.7-967.3)	490.6±83.4 (358.1-673.1)	28.2%
16-slice	180.6±57.7 (74.0-337.0)	152.6±90.4 (49.0-335.0)	16.8%

Table 3: Noise SD

Detector	Before time reduction	After time reduction	Increase
4-slice	18.3±4.5 (8.6-28.5)	18.5±2.5 13.8-22.3)	0.2
16-slice	39.0±23.6 (17.9-87.3)	43.9±22.8 (8.8-75.8)	4.3

DISCUSSIONS

Reduction of dose remains to be a challenge in CT scans. Nevertheless it is associated with increase in noise. Image Noise is one of the primary factors in CT Image Quality Noise (specifically, quantum noise) is generally characterized by graininess, or a salt and pepper pattern on the image.

In this study, the scan exposure parameters for 4-Slice scanner were 120 kVp and 200 m As and standard pitch of 1.0 and rotation time 1.0 sec. Keeping these parameters constant only changing in the Time per rotation to 0.7 sec the reduction in dose was evaluated.

For 16-Slice scanner the exposure parameters were 120 kVp and 100mAs and a pitch of 0.87and rotation time 0.7 sec. After changing the rotation time to 0.5 sec with the same scan exposure parameters reduction to dose was also examined. The increase in noise determined by increase in Hounsfield units was tested.

The CTDI is defined to represent an approximation to the average absorbed dose to a particular location in a standard acrylic phantom from multiple CT slices. CTDIw is a weighted average of the CTDI's at the center and periphery of the phantom. CTDIvol is similar to CTDIw but also includes the effect of pitch on the radiation dose. It is the CTDIvol that is displayed on the CT console and dose report. $CTDI_{vol}$ is a useful indicator of the radiation output for a specific exam protocol, because it takes into account protocol-specific information such as pitch. In this study the mean $CTDI_{vol}$ for the 4-Slice was 20.60 mGy before rotation time reduction and 14.6 mGy afterwards. And the reduction obtained was 34.1%.For the 16 –Scanner the mean $CTDI_{vol}$ before and after rotation time reduction were 4.67mGy and 4.40mGy respectively.

The dose length product (DLP) is an indicator of the integrated radiation dose of an entire CT examination, or radiation deposit in patients. The DLP for the 4 –Slice scanner was reduced by 28.2% after rotation time reduction. For the 16-Scanner the reduction was 16.8.

The reduction in dose was slightly less than that obtained by reducing the m As and pitch (10) but was still significant while reproducing acceptable images Noise is one of the primary factors in CT Image Quality Noise (specifically, quantum noise) is generally characterized by graininess, or a salt and pepper pattern on the image. Noise is inversely related to the number of X-rays. In our study there was no significant change in the noise for the chest exam for 4-Slice scanner which increased from 18.2HU to 18.5HU. However there was a significant change in the 16-Slice scanner the mean noise increased from 39.0 to 43.9 HU. The image was still within in the acceptance range. The challenge is in finding a balance between dose and noise that allows the images to be of diagnostic quality while utilizing the lowest dose possible.

CONCLUSION

CT radiation dose optimization and reduction is a complex process that seems to stay motionless since years. Several parameters can result in dose reduction. Reducing the rotation time was found to significantly reduce the dose. The rotation time reduction is limited by the amount of increase in noise. A significant reduction in CTDIvol and DLP were observed with the 4-slice scanner, with a considerably low increase in noise. A lower reduction in dose and larger increase in noise was observed with the 16-slice scanner. The results are encouraging for further efforts in reducing the CT dose without compromising the clinical findings with an aim to fulfill the optimization requirements

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