

## Evaluation of image quality in CT chest by 50% mAs reduction

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### Abstract

**Introduction:** Conventional chest CT is usually performed in the setting between 220-280 mAs. Increase use of CT in recent times has the potential to increase radiation burden to the general population. The purpose of this study was to evaluate the image quality in CT Chest with 50% mAs reduction.

**Methods:** This prospective study was done in 101 patients with age above 18 years and BMI less than 25kg/m<sup>2</sup> who were referred for CECT chest examination. A 16 slice multi detector CT scanner was used to acquire non contrast at 120 kVp and 140 mAs, a modified protocol with 50% reduction in mAs and contrast enhanced scan at standard protocol of 120 kVp and 280 mAs. The images of plain and contrast enhanced scans were evaluated by two expert radiologists and given the image quality score in 5 point scale (1-worst, 2-suboptimal, 3-adequate, 4-good, 5-excellent) to each. Image noise was measured in images of each patient. Patient weight, height and BMI were recorded and correlated with image quality score. Statistical analysis was done with relevant test.

**Results:** The overall image quality with standard protocol was significantly better ( $p < 0.05$ ) than modified protocol. The modified protocol had acceptable image quality score for patients with weight < 60 kg, BMI < 25kg/m<sup>2</sup>. The CTDI<sub>vol</sub> was 11.15 with reduced mAs and 22.15 with standard mAs resulting in significant reduction in radiation dose of about 49%.

**Conclusion:** Image quality of modified protocol with 50% mAs reduction i.e. 140 mAs is acceptable for average built patients and not patients with large anthropometric parameters.

**Key words:** Computed Tomography, mAs reduction, Image quality, Noise, Radiation dose.

### Introduction

Computed Tomography (CT) also known as computed axial tomography is a valuable radiological diagnostic imaging modality.<sup>1</sup> Today MDCT examination comprises 7 % of all radiological examination contributing more than 40% radiation dose. Usually standard protocol are used for the CT examination and the technical parameters (kVp, mAs, pitch, filter & scan length) are typically constant and not adjusted accordingly to different body habitus of patients.<sup>2, 3, 4</sup> The CT image quality is influenced by scanning parameters as well as the patient biometrics. It is essential to determine the optimal tube current for different biometric range which produces diagnostically acceptable images. Furthermore by establishing the relationship between

image quality and patient parameters the exposure factors could be selected accordingly. Chest CT is widely used for evaluating a multitude of abnormalities and disorders affecting the airway, mediastinum, and lungs. Conventional chest CT is usually performed using settings between 220-280 mAs. Increased use of CT in recent times has led to increase radiation burden to the general population. In the United States, CT accounts for more than two thirds of the total radiation dose from radiological examination.<sup>5</sup> The principle of ALARA (as low as reasonably achievable) is more relevant in this era of increasing use of CT for diagnosis and interventional procedures. Several studies have suggested that substantial dose reduction during chest

CT is feasible because of the high inherent contrast in the chest with lower pulmonary absorption of radiation. We hypothesized that of images of chest CT with a 50% reduction mAs can be performed without seriously jeopardizing the image quality.<sup>6</sup> Low dose CT protocol has been recommended for lung cancer screening as well as for follow up scans. Studies have shown low tube current CT protocol enable reliable measurement of the soft-tissue attenuation of pulmonary lesion. For multiple follow up study also dose reduction is mandatory. Dose can be reduced by reducing mAs but reducing the mAs may lead to increased noise in image. Till date no such study has been done in ours settings.

### Methodology

This was a prospective cross-sectional study carried out in the Department of Radiology and Imaging, Tribhuvan University Teaching Hospital, Kathmandu. The study cases that underwent chest CT scans for various clinical indications with Age > 18 years. A total of 101 patients included in the study from July 2014 to December 2014. The exclusion criteria included BMI > 25, and pediatric patient with age < 18 yrs, uncooperative, traumatized and non-Nepalese patient. The study protocol was approved by the ethical committee of institutional review board of the institute of medicine.

Written informed consents were taken from each patient. In the Neusoft's NeuViz 16 CT scanner, CT of chest was performed from root of neck to umbilical level. Volumetric data were obtained for non-contrast phase with 50% mAs reduction protocol (120 kVp, 140 mAs, pitch 0.8631 collimation of 0.625 mm, Gantry rotation

0.75s, FOV 300mm and matrix 512x512). The contrast scan was obtained during venous phases after 55 sec of contrast injection with standard protocol (120kVp, 280 mAs, pitch 0.8631, and collimation of 0.625mm, gantry rotation 0.75s, FOV 300mm and matrix 512x512). Both plain and contrast scans were performed in single breath hold. Image noise in both studies at erector spinae muscle (at the level of fourth chamber) was measured. These images were blindly reviewed in workstation for quality scoring (1-worst, 2-suboptimal, 3-acceptable, 4-verygood, 5-excellent) by two radiologists with equal expertise on chest CT interpretation and gave the score for images of each protocol. Image noise for both scans was measured at erector spinae muscle at level of four chambers of the heart. The radiologist gave quality score of images based on subjective criteria given by European guidelines.<sup>10</sup> Statistical analysis was done by relevant statistical tests i.e. Wilcoxon's signed rank test and Pearson's correlation coefficient. A 95% confidence interval was taken, and  $p < 0.05$  were termed as statistically significant.

### Results

In 101 patients, 58 (57.4%) were male and 43 (42.6%) were female. Different biometric parameters i.e. age, weight, height, BMI of subjects were measured and average mean, range and standard deviation were calculated. (Table 1) The mean age was 48 and range was 18-86 years. The patients had weight with maximum of 75 kg and minimum of 35 kg with mean of 51.85 kg. The height ranged between 1.5 to 1.6 m. The highest BMI was 25 kg/m<sup>2</sup> and lowest was 14.89 kg/m<sup>2</sup> with mean was 20.62 kg/m<sup>2</sup>.

**Table 1. Measurements of characteristics features of enrolled subjects**

Parameters	Average Mean	Standard deviation	Range
Age (yrs.)	48.42	19.10	69
Weight (kg)	51.85	8.49	40
Height (m)	1.58	0.08	0.33

### Average image quality score comparison

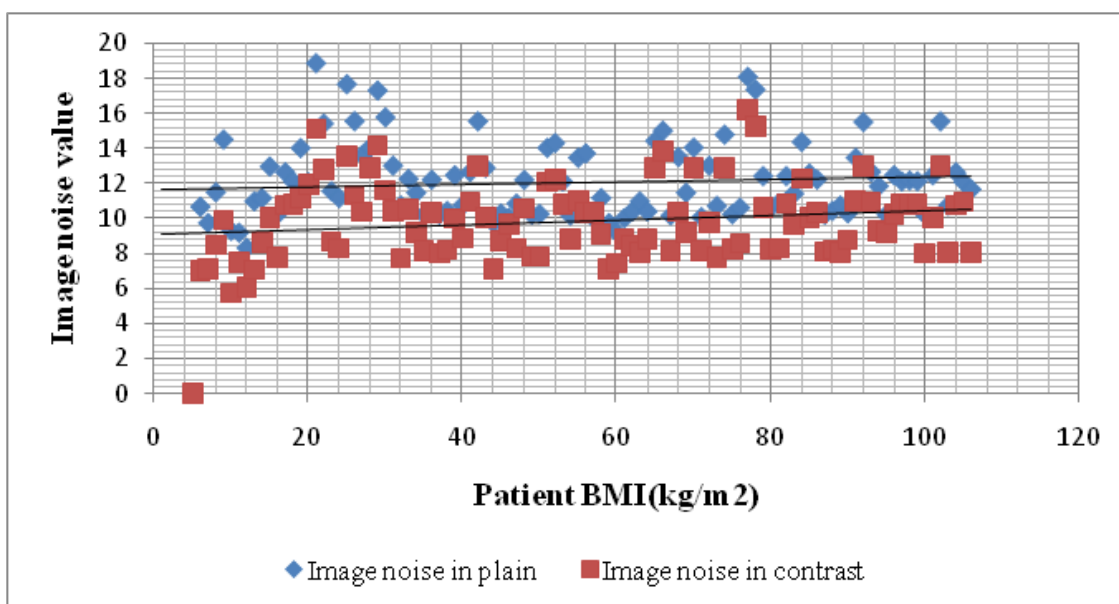
The image quality score for protocols with standard and modified mAs was assessed by Wilcoxon signed rank test. The image quality of standard protocol was found to be significantly better than that of modified protocol. (Table 2)

**Table 2. Average results of quality score by two radiologists for different scanning protocol**

Observers	Protocols	
	Plain CT	Contrast CT
Radiologist A	3.26	4.13
Radiologist B	3.27	4.10

**Relationship between image noise and patient biometrics**

Image quality was also assessed by image noise values. Image noise was significant and higher in modified protocol with mean noise of 12.17. The average image noise value in standard protocol was found significantly low 9.92. As BMI of patient increased more noise was found. For the patients with BMI of 25 kg/m<sup>2</sup> image noise value in modified protocol was higher than 18. There was less variation in values of image noise with lower BMI. The image noise was found to be progressing linearly with each increment in BMI of patients. (Fig 1)

**Figure 1. Relation between image noise and BMI****Correlation of image quality with patient's biometrics**

The image quality score was associated with different patient parameters. Their correlation with image quality was calculated by Pearson's correlation coefficient using P - value. At standard dose, the image quality had highest correlation with patient weight followed by height. Whilst at reduced dose level, the highest correlation was found with patient weight & there were least correlation of image in quality score with BMI of patients in both protocols (Table 3).

**Table 3. Statistical correlation between image quality score and biometrics of patients with reduced dose protocols.**

Parameters	Correlation coefficients	P – value
Weight	-0.13	0.000
Height	-0.21	0.000
BMI	-0.36	0.000

### Estimation of dose

We estimated the average effective dose by using European conversion coefficients (0.014 for chest) to the DLP value that was displayed on the scanner. The scanner displayed both CTDI<sub>vol</sub> and DLP. Significant amount 49% of radiation dose reduction was found with 50% mAs standard protocol for equivalent scan length (Table 4).

**Table 4. Comparison of effective dose on different protocols**

Protocols	CTDI <sub>vol</sub> (mGy)	Average DLP (mGy.cm)	Estimated Effective dose (mSv)
Plain CT (140 mAs)	11.15	423.94	5.93
Contrast CT (280 mAs)	22.44	849.84	11.89

### Discussion

CT scan is a modality which contribute significant amount of radiation dose to patients with greater contribution from chest scans. Though CT constitutes only about 7% of radiological examination, it contributes more than 40% of radiation exposure from medical x-ray sources. Although other imaging modalities which do not use ionizing radiation like USG, MRI are being used as alternative technique to CT, but for chest imaging CT is still the most preferred technique till date. Minimizing radiation hazard is of prime importance in CT examination. The use of reduced mAs in non-contrast phase is one of the options for reducing radiation dose. This study was conducted with 50% mAs reduction (140 mAs) in plain study of the chest. The result showed diagnostically acceptable image quality in average and in thin built adult patients with significant reduction of radiation hazard. A range of patient's biometrics was also identified where a low mAs scanning is possible without changing the kVp.

Srinivas R Prasad et al. performed CT chest study with 50% dose reduction (220-280 mAs versus 120-150 mAs) found good inter-observer agreements and concluded that 50% dose reduction is possible for normal weight patients(mean score-3.4) which was nearly similar to our study.<sup>7</sup>Johan R Mayo et al. performed CT chest with two fold reduction of mAs (200 mAs and 140 mAs).This study showed that there was no significant change in image quality even with 140 mAs for average built patient.<sup>8</sup> This study showed similar with the present study. The normal structures were better visible with standard dose ( $P <$

0.05),anddifferences were found in the detection of lung and mediastinal abnormalities. Han et al. did a study to establish the correlation between patients biometrics and image quality.They reported that BMI is the best parameter to correlate with quality score. Our study evaluated other additional parameters like patient weight and height and found that image quality score at standard protocol correlated best with BMI and least with height. In this study he also found that patient's weight correlated best with image quality score when low dose protocol was used for average patients. In the present study there was significant negative correlation between patient biometrics and image quality. Despite more weight image quality scores were high in few patients; this might be due to subjective perception of radiologist. Various studies have given the range of values for noise in CT images which are diagnostically acceptable.

Kamdakone et al. concluded that noise of 18-25 are diagnostically acceptable. Our study showed the average values of noise as 12.28 for reduced tube current and 9.92 for standard protocols which are significantly lower.<sup>9</sup> Thus image noise measured at erector spine muscle was not always reliable for image quality scoring as some images had good quality score despite significant. We tried to estimate the possible reduction in radiation dose during chest scan by using low tube current technique where the data of dose CTDI<sub>vol</sub> data was used. The present study showed that significant dose reduction of about 49% is possible in modified protocol (based on CTDI<sub>vol</sub> data we had estimated the possible radiation dose with in CECT scan of chest with

30cm scanning length). The present study showed that if dual-phase studies (plain and contrast) are done with standard protocols the total effective dose for CT chest is 23.78 mSv and with reduced tube current for plain CT it would be 17.82 mSv which is equivalent to 18 % dose reduction.

## Conclusion

The present finding showed that there is good correlation between image quality score and patient weight, height and BMI. The quality of image with standard dose is better than reduced dose with  $p < 0.05$ . The patient weight best correlated with reduced dose ( $r = 0.13$   $p < 0.05$ ). This study recommends patient specific exposure protocol and with low mAs for patient up to  $< 60$  Kg weight, BMI  $< 25$  kg/m<sup>2</sup> for non-contrast phase of CT chest. Although various methods can be utilized for dose reduction i.e. tube current modulation, proper pitch and kVp selection, by applying low mAs technique is suitable for plain CT as well as CECT in follow up study, cancer screening study and CT guided FNAC. We recommend that further study involving larger number of participants would be more valuable.

**Conflict of interests:** None Declared

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