The Evaluation of Overexposure Effect on Computed Radiography

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1. Introduction

This research was accomplished to assess image quality changes with reduced and increased dose in chest computed radiography (CR), ultimately to find the minimum dose that provides necessary resolution requested by the clinical chest diagnosis and reduced radiation exposure to a patient. Most of the radiological diagnoses especially for abdominal and head diagnosis are currently dependant on computed tomography (CT) because that CT is superior to general radiography (GR). CT provides sectional sliced view and 3-D anatomy with high resolution. Nevertheless of the advantages of the CT many of the chest diagnoses including basic preoperative diagnostic procedures, for example, a tubercle diagnosis are still in reliance upon general radiography. Film imaging system has been used for GR, but recent years computed radiography (CR) is substituting for film imaging system because that CR is cheap in long term carrying charge, make it easy to store images at a small data storage device instead of large film storage room, and is suitable to picture archiving and communication system (PACS). When the CR was first introduced to the clinic it was announced that CR could reduce radiation exposure to the patient with many other benefits, but recent studies show that CR causes over exposure to the patient than traditional film-screen system.[1,2,3,4] In contrast to the film-screen system, because that the over exposure in CR increases signal to noise ratio (SNR) which is result in the better image quality, the radiological technician is tend to over exposure in clinical radiology. It causes different effect in film-screen system, because the over exposure or under exposure makes the film over developed or under developed which is result in unreadable image.

2. Methods and Results

Modulation transfer function (MTF), normalized noise power spectrum (NNPS), and noise equivalent quanta (NEQ) corresponding to the different doses were measured for the assessment of image quality. The analysis of NPS, MTF, the preparation of "edge test device" used in MTF measurement and experimental setups were followed by the recommendations of International Electrotechnical Commission (IEC).[5] Before imaging edge test device, exposure dose with different beam current were measured using Victoreen 06-524-3000 ion chamber and RAD-CHECK^{TM} X-ray exposure meter. X-ray source used for the experiment was Toshiba LTN-25 assembled by Listem. Agfa CR30-X digitizer Computed Radiography system and 24 x 30 cm (9.5 x 12") imaging plate was used.[6] MATLAB 7.1 was used to analyze imaging quality.

2.1 Experimental Setup and Dose Measurement

Experimental setup for exposure dose measurements and image acquisition was as shown in the Fig. 1. Experiments were accomplished with fixed tube voltage and exposure time (55 kV_p , 25msec) and various beam currents. Tube voltage was fixed at 55 kV_p because it was manufacturer-providing AEP setting value for "Chest AP" projection imaging.

Figure 1. The figure of experimental system setup and arrangement of edge test device and ion chamber.

2.2 CR imaging System

CR imaging system is an indirect digital imaging system using imaging plate (IP) and reader.[7] The pixel size and pixel matrix size of used IP in the experiments was 100 micron and 2328 x 2928 respectively.

2.3 NPS Analysis

The results of NPS analysis was summarized in Fig. 2. Figure 2 shows that the increased exposure reduces noise power because it increases signal to noise ratio.

2.4 MTF Analysis

The MTF is a measure of signal transfer over a range of spatial frequencies and quantitative reference for image sharpness. [8] The MTF characteristics were measured using the "edge test device" in accordance with the recommendation of IEC. Measured pre-sampling MTF is shown in Fig. 3. It was shown that the over exposure by increasing beam current does not improve image resolution, which does agree with the Lubbert's effect.

The spatial frequencies measured at 10% MTF were about 4 lp/mm without meaningful differences regardless of significant changes in exposure conditions.

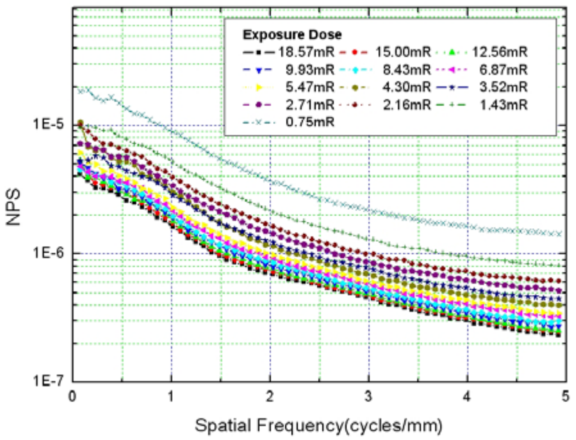

Figure 2. Summary of the measured NPS for various exposure doses at the same tube voltage of 55 kV_p.

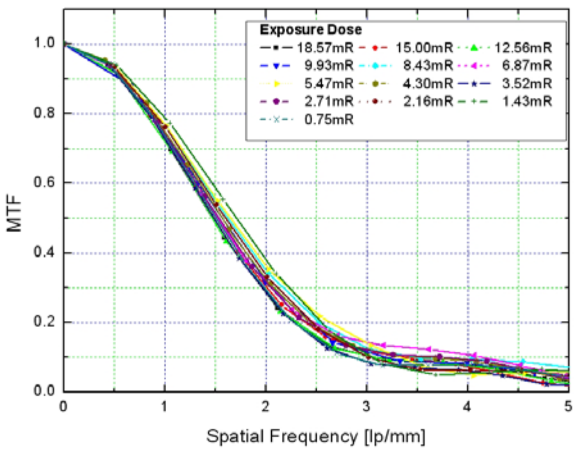

Figure 3. Measured pre-sampling MTFs for various exposure doses at the same tube voltage of 55 kV_p.

2.5 NEQ Analysis

NEQ is the measure of absolute measure of image quality as a function of frequency ranges from zero to infinite.[8] NEQ didn't show significant changes with the exposure dose between 18.57mR and 5.47mR although there was a significant difference between NEQ at the AEP setting dose (0.75mR) and, very low dose (6.87mR). The result shows that overexposure than AEP setting dose by increasing beam current does not improve image quality. Moreover, even the lower dose, 5.47mR, could provide the same quality.

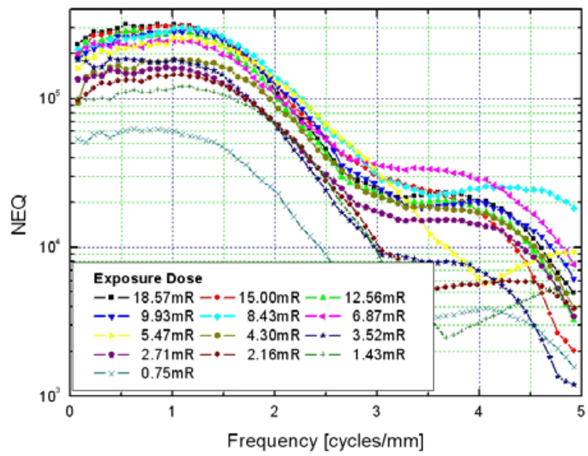

Figure 4. Measured NEQ for various exposure doses at the same tube voltage of 55 kV_p.

3. Conclusions

It was shown by the experimental analysis that the overexposure in chest CR by increasing beam current does not improve NEQ, the overall image quality perceived by human, although it reduces noise power of the image. The experimental resultant facts show that the resolution does not change with exposed dose, and it is clearly revealed even with factor of two over exposure than AEP setting dose does not improve NEQ in chest CR image.

The results could be used as a reference data for dose optimization in the clinical radiology, and might be a critical role for reducing patient exposure.

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