Correlation Between Image Noise and Body Weight in Coronary CTA with 16-row MDCT[1]

Norihiko Yoshimura, Adeel Sabir, Takeshi Kubo, Pei-Jan Paul Lin, Melvin E. Clouse, Hiroto Hatabu

Rationale and Objectives. To evaluate the correlation between image noise and body weight (BW) or body mass index (BMI) in coronary computed tomography angiography (CTA) as a potential parameter for reducing radiation dose in coronary CTA.

Materials and Methods. Thirty-six patients who underwent electrocardiogram-gated cardiac CT were analyzed in this study. The patients included 26 men and 10 women with a mean age of 60 years (range 43–79 years). All patients were imaged on a 16-row multidetector CT scanner. Mean value of BW and BMI was 83.5 kg and 28.1, respectively. Image noise was defined as standard deviation (SD) of the attenuation values measured by using 1 cm^2 circular region of interest in the ascending aorta at the level of the right main pulmonary artery. The SD values were plotted against BW and BMI. The correlations were examined using a linear regression method. A P value of less than .05 was considered significant.

Results. The r value of linear regression between noise and BW was 0.90 ($P < .001$). The r value of linear regression between noise and BMI was 0.74 ($P = .015$).

Conclusions. Excellent correlation was observed between noise and BW in coronary CTA. These data may be used as potential parameters for customized radiation dose modification to reduce radiation dose in coronary CT examinations.

Key Words. Coronary CT; radiation dose; body weight; image noise.

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Coronary artery disease is the leading cause of death in the United States, accounting for approximately 500,000 deaths every year. The annual incidence of myocardial infarction is nearly 1.5 million. Selective conventional coronary angiography has been a standard in diagnosis of coronary artery diseases (1–3). However, it is now appreciated that the accumulation of atherosclerotic plaque in the coronary arterial wall begins earlier than the development of luminal stenosis. With the advent of multirow detector computed tomography (CT), coronary CT angiography (CTA) with electrocardiogram (ECG) gating is emerging as a viable means of imaging the coronary arteries and coronary arterial wall (4–10). Traditionally, prospective ECG gating was used in cardiac CT examination. Recently, retrospective ECG gating has been preferentially employed for ECG-gated coronary CTA. Retrospective ECG-gated scanning is performed with a slow table motion and simultaneous recording of the ECG trace, which is used for retrospective linkage of scan data with particular phases of the cardiac cycle. Retrospective ECG gating using a low pitch factor allows for postprocessing reconstruction at the time point when image quality is optimal. However, because low pitch factor leads to increased radiation dose, excessive radiation is an ongoing limitation of retrospective ECG gating (11).

Radiation dose from diagnostic x-ray has been shown to increase the lifetime cancer mortality risks. In 14 developed countries, estimated attributable risk of cancer ranged from 0.6% to 1.8% (12). Radiation dose, there-

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[1] From the Department of Radiology, Beth Israel Deaconess Medical Center, 330 Brookline Avenue, Boston, MA 02215. Received August 2, 2005; accepted November 15, 2005. **Address correspondence to**: N.Y. e-mail: nyoshimu@bidmc.harvard.edu

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fore, should be minimized as much as possible (13). ECG-controlled tube current modulation is one method for reducing radiation dose in retrospective ECG-gated cardiac examinations (14).

Furthermore, it is well known that image noise correlates with biometric data such as body weight (BW) and body mass index (BMI) (15–17). The standard protocol with fixed tube current-time settings can lead to an overexposure in patients with lower BW. Therefore, to reduce the radiation dose to the patient, an individually weight-adapted examination protocol would be another method of radiation dose reduction in coronary CTA (18). To our knowledge, significant correlation between image noise and BW or BMI has not been reported in coronary CTA. The purpose of this study was to evaluate the correlation between image noise and BW or BMI in coronary CTA as a potential parameter for reducing radiation dose in coronary CTA.

MATERIALS AND METHODS

Forty-seven patients who underwent ECG-gated coronary CTA were retrospectively reviewed. Eleven patients were subsequently excluded from analysis because of differences in parameters such as tube potential, tube current, and collimation. Thirty-six patients were analyzed in this study. Included in the 36 patients were 26 males and 10 females with a mean age of 60 years (range 43–79 years). We obtained institutional review board approval to review the patient's charts and imaging studies. BW and height (H) values were obtained from the clinical chart. BW ranged from 52.3 to 127.3 kg (mean 83.5, standard deviation [SD] 16.3 kg). Height ranged from 150.0 to 188.0 cm (mean 172.3, SD 9.7 cm). We used BW, BMI, BW/H, and $\sqrt{BW/H}$ as biometric data. BMI was calculated as follows: BMI = BW/H^2. BMI ranged from 18.7 to 37.5 kg/cm^2 (mean 28.1, SD 4.2 kg/cm^2).

All CT scans were performed on a 16-row Multi-Slice CT Scanner (Toshiba Aquilion 16 CFX, Toshiba America Medical Systems, Tustin, CA) with a collimation of 16 × 0.5 mm, pitch factor 0.25, gantry rotation time 400 milliseconds, tube current 350 mA, and tube potential 135 kVp. Scan data from a 180° + fan angle (49.2°) was used to reconstruct axial images. Reconstructed field of view ranged between 180 and 240 mm. Ninety milliliters of nonionic iodinated contrast material Ioversol (Optiray 350, Tyco Healthcare, Mansfield, MA) was injected in the right antecubital vein at a rate of 4–5 mL/second using a power injector (Medrad, Indianola, PA) followed by a 20–30 mL saline chaser bolus. Automated bolus tracking was used by placing a circular region of interest in the ascending aorta at the level of the coronary ostia and acquisition was triggered when the average attenuation value in the region of interest reached 180 Hounsfield Unit. All patients were scanned in cranial caudal direction from slightly above the coronary ostia to the diaphragm, covering an average range of 120 mm.

Retrospective ECG gating was used to reconstruct images from the acquired raw data, using a medium sharp convolution kernel and an image matrix size of 512 × 512 pixels. Multisegment reconstruction was used with temporal resolution ranging between 100 and 230 milliseconds. Axial images with contiguous 0.5 mm thickness were reconstructed. The R-R interval was divided into 10 phases at intervals of 10%, and the resulting DICOM images were transferred to an advanced workstation (Vitrea 2, Vital Images, Plymouth, MN) for further analysis. The best image set (ie, with the least motion artifact was selected for analysis).

Image noise was defined as standard deviation of the attenuation values measured by using 1 cm^2 circular region of interest in the ascending aorta at the level of the right main pulmonary artery. The image noise values were plotted against BW, BMI, BW/H, and $\sqrt{BW/H}$. Correlation between image noise and biometric data was evaluated both in overall population and by male/female.

Statistical Analysis

The relationship between image noise and BW, BMI, BW/H, or $\sqrt{BW/H}$ was evaluated using simple linear regression. A P value of less than .05 was considered significant. SPSS software (version 12.0; SPSS, Chicago, IL) was used for all statistical analyses.

RESULTS

Image noise ranged from 9.2 to 38.1 (mean 19.8, SD 6.8). The r value of linear regression between image noise and biometric data of BW, BMI, BW/H, and $\sqrt{BW/H}$ is summarized in Table 1. Image noise and BW showed the best correlation with r value of 0.90 in the overall population, males, and females. Image noise and BMI showed the best correlation with r value of 0.95 in females. Image noise significantly correlated with all biometric data in the overall population: BW ($P < .001$), BMI ($P = .015$), BW/H ($P < .001$), and $\sqrt{BW/H}$

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