Original Article

Quantitative assessment on coronary computed tomography angiography (CCTA) image quality: comparisons between genders and different tube voltage settings

Teo Chee Chian[1], Norziana Mat Nassir[1], Mohd Izuan Ibrahim[1], Ahmad Khairuddin Md Yusof[2], Akmal Sabarudin[1]

[1]Diagnostic Imaging & Radiotherapy Program, School of Diagnostic and Applied Health Sciences, Faculty of Health Sciences, Universiti Kebangsaan Malaysia, 50300 Kuala Lumpur, Malaysia; [2]Department of Cardiology, National Heart Institute, 50400 Kuala Lumpur, Malaysia

Correspondence to: Dr. Akmal Sabarudin. Diagnostic Imaging & Radiotherapy Program, School of Diagnostic and Applied Health Sciences, Faculty of Health Sciences, Universiti Kebangsaan Malaysia, Jalan Raja Muda Abdul Aziz, 50300, Kuala Lumpur, Malaysia.
Email: akmal.sabarudin@ukm.edu.my.

Background: This study was carried out to quantify and compare the quantitative image quality of coronary computed tomography angiography (CCTA) between genders as well as between different tube voltages scan protocols.
Methods: Fifty-five cases of CCTA were collected retrospectively and all images including reformatted axial images at systolic and diastolic phases as well as images with curved multi planar reformation (cMPR) were obtained. Quantitative image quality including signal intensity, image noise, signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) of right coronary artery (RCA), left anterior descending artery (LAD), left circumflex artery (LCx) and left main artery (LM) were quantified using Analyze 12.0 software.
Results: Six hundred and fifty-seven coronary arteries were evaluated. There were no significant differences in any quantitative image quality parameters between genders. 100 kilovoltage peak (kVp) scanning protocol produced images with significantly higher signal intensity compared to 120 kVp scanning protocol ($P<0.001$) in all coronary arteries in all types of images. Higher SNR was also observed in 100 kVp scan protocol in all coronary arteries except in LCx where 120 kVp showed better SNR than 100 kVp.
Conclusions: There were no significant differences in image quality of CCTA between genders and different tube voltages. Lower tube voltage (100 kVp) scanning protocol is recommended in clinical practice to reduce the radiation dose to patient.

Keywords: Coronary computed tomography angiography (CCTA); coronary artery; quantitative image quality assessment; genders; kilovoltage peak (kVp)

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Introduction

Multi-detector computed tomography (MDCT) created a new milestone in artifact-free cardiac and coronary artery imaging with large volume coverage (1). Advanced MDCT system (64-slice and above), widened the scope of coronary computed tomography angiography (CCTA) to visualize coronary artery wall morphology, characterize atherosclerotic plaques, identify non-stenotic plaques, and detect coronary luminal changes. Thus, the prognosis of coronary artery disease (CAD) can be provided efficiently by the less invasive CCTA method (2). Besides, Sun & Lin (3) have reported that CCTA has sensitivity and specificity of more than 97% and 87% respectively, with the use of 64-slice MDCT in the detection of CAD. Also, due to the high negative predictive value (>95%) of CCTA, it has become a reliable imaging modality for heart screening. It allows patients to choose between non invasive CCTA or an invasive coronary angiography examination for coronary artery assessment (4). These achievements and success of CCTA were attributed to rapid evolution of CT technology, which also enabled in producing CCTA with high image quality.

With the extensive use of CCTA in the current practice, radiation dose received by the patient during CCTA must not be neglected. 100 kilovoltage peak (kVp) scan protocol was proven to reduce the radiation dose to the patient significantly without compromising the image quality (5,6). However, 100 kVp scan protocol is limited to patient with low body mass index (BMI) (<25.0 kg/m^2) (5,6). In the previous literature, there was an evidence of physiological differences in heart rate between genders, in which males had lower resting heart rate than females (7). Such change in resting heart rate does not affect the heart rate consistency and image quality during CCTA examination (8).

The primary objective of all imaging examinations is to produce a high diagnostic quality image. In other words, the precision and consistency of entire coronary tree to be visualized in CCTA examination is of paramount importance (9-12). When a new protocol or technique is implemented in CCTA, the image quality is an important subject matter to be discussed including the sensitivity and specificity tests to detect particular diseases and the measurements of qualitative and quantitative assessment. Several studies comparing different CT technical parameters emphasized that the image quality has to be at the optimum level for diagnosis (13-18). However, both qualitative and quantitative image quality were not discussed by some authors in terms of gender differences (16,17). Therefore, this study was carried out to quantify and compare the objective image quality between genders as well as between different tube voltages scan protocols.

Methods

Study design & population

This study was approved by the institutional ethics committee (IJNEC/05/2013) (01). Fifty five sets of CCTA were obtained retrospectively at National Heart Institute, Kuala Lumpur from January 2015 to March 2016. The images were selected randomly from patients who underwent CCTA for CAD assessment. However, patients with a history of previous heart surgery (e.g., pacemaker implantation, coronary artery bypass grafting, percutaneous coronary intervention and others) were excluded from this study.

CCTA scanning method

CCTA protocol was performed with a Somatom Definition 64-slice DSCT (Siemens Medical Solutions, Forchheim, Germany) with beam collimation of 2 mm × 32 mm × 0.6 mm, slice acquisition of 2 mm × 64 mm × 0.6 mm with the z-flying focal spot, 320 mAs per rotation and tube voltage between 100 and 120 kVp. The ECG-pulsing window was set at 30–80% of the R-R interval with a pitch of 0.2–0.43, which was automatically adapted to the heart rate.

Although the standard adult CCTA protocol is recommended with a tube voltage of 120 kVp, it is possible to reduce the tube voltage to 100 kVp in small-sized patients without compromising the image quality (19). A 100 kVp protocol was only used in patients scanned with BMI) less than 29 and 27 kg/m^2 for males and females, respectively.

Contrast medium administration

A minimum of 65 mL contrast agent (Iomeron 350 mg/mL) was administered intravenously at a flow rate of 5.0–5.5 mL/s followed by 50 mL saline flush at 5 mL/s. The amount of contrast medium required for coronary CT examination was calculated according to the following formula: V = IR × ST, where V is volume in milliliters, IR is injection rate (mL/s), and ST is scanning time in seconds (20). Bolus was tracked using an automated bolus triggering technique at the ascending aorta, with a baseline threshold of 120 Hounsfield units (HU).

Quantitative image quality analysis

Quantitative image quality was measured on three types of images in Digital Imaging and Communication in Medicine (DICOM) format; consisted of reformatted axial images with a slice thickness of 0.75 mm at (I) systolic phase; (II) diastolic phase and (III) curved multiplanar reformation (cMPR) (*Figure 1*). Four main coronary arteries—right coronary artery (RCA), left anterior descending artery (LAD), left circumflex artery (LCx) and left main artery (LM) were evaluated individually by a single reader for all patients.

Figure 1 The cMPR images of RCA (A), LAD (B) and LCx (C). cMPR, curved multi-planar reformation; RCA, right coronary artery; LAD, left anterior descending artery; LCx, left circumflex artery.

Objective image quality parameters such as signal intensity, image noise, signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) were quantified with software Analyze version 12.0 for Windows 7 (Analyze Direct Inc., USA). Two circular regions of interest (ROIs) with the possible largest area that ranged from 3.5 to 13.8 mm^2 were placed randomly along the coronary artery to obtain quantitative image quality measurements. The ROIs were placed carefully to avoid calcifications, plaques, vessels wall and any other artifacts. For quantification of signal intensity of cardiac wall, two ROIs with area ranged from 4.1 to 13.4 mm^2 were placed randomly over the cardiac wall. ROIs placements were done with optimum window width/window level of 800/300.

Signal intensity was derived from mean CT attenuation values measured in HU averaged from two ROIs. Image noise was defined as the mean standard deviation of CT attenuation values within these two ROIs. SNR and CNR of coronary artery were calculated using the following formulae: SNR = SI/noise; and CNR = $(SI_{CA}–SI_{CW})$/noise, where SI is signal intensity, SI_{CA} is signal intensity at coronary artery, and SI_{CW} is signal intensity at the cardiac wall.

Statistical analysis

Statistical analysis was performed using software SPSS version 22.0 for Windows (SPSS Inc., USA). All quantitative image quality parameters were presented in mean ± standard deviation. Independent *t*-test was performed for comparison of image quality between males and females as well as between scan protocol of 100 and 120 kVp for each coronary artery. P value <0.05 was considered statistical significant.

Results

Patient characteristics

Fifty five subjects (31 males and 24 females) with mean age of 55±10 years were involved in this study. A 100 kVp scan protocol was applied to 33 subjects (22 males and 11 females) with mean BMI value of 23.29±2.60 and 25.24±2.53 kg/m^2 for males and females, respectively while 120 kVp scan protocol was applied to 22 subjects (9 males and 13 females) with mean BMI value of 31.84±4.30 and 31.67±4.49 kg/m^2 for males and females, respectively.

Quantitative image quality

Six hundred and sixty coronary arteries from three types of images (220 coronary arteries from each type of images) were evaluated in this study. However, owing to an anatomical variant in one patient (LCx was absent) the images were not evaluated. Therefore, a total of 657 coronary arteries were quantified to obtain its objective image quality. All quantitative image quality parameters are presented in *Table 1*.

The comparison of quantitative image quality parameters between genders is presented in *Table 2*. There were no significant differences in all quantitative image quality parameters between males and females. However, signal intensity was significantly higher in males than females in LAD on axial images at diastolic phase (419.24±110.18 for males *vs*. 350.54±127.51 for females, P=0.04). Consequently, this leads to a significant increase in SNR and CNR in males as compared to females (SNR: 10.05±3.80 for males *vs*. 7.34±3.56 for females, P=0.01; CNR: 7.41±3.08 for males *vs*. 5.03±2.98 for females, P=0.01).

Table 1 Quantitative image quality of CCTA

Coronary artery	Quantitative image quality parameters			
	Signal intensity	Noise	SNR	CNR
LAD				
Axial systolic phase	387.87±111.67	49.77±18.32	8.37±2.69	5.97±2.25
Axial diastolic phase	389.26±121.87	48.22±16.17	8.86±3.91	6.37±3.23
cMPR	398.74±112.44	48.14±19.76	9.26±3.50	6.72±2.85
LCx				
Axial systolic phase	389.13±108.74	58.18±21.35	7.30±2.53	5.18±1.95
Axial diastolic phase	393.58±114.72	58.29±24.26	7.73±3.50	5.54±2.78
cMPR	405.10±111.67	50.61±22.89	9.09±3.53	6.56±2.78
RCA				
Axial systolic phase	404.73±111.11	46.98±17.09	9.34±3.15	6.75±2.43
Axial diastolic phase	416.90±128.06	45.85±16.92	9.88±3.92	7.19±3.12
cMPR	435.79±123.04	46.74±20.10	10.79±5.45	7.99±4.52
LM				
Axial systolic phase	415.76±112.01	35.26±10.22	12.61±4.50	9.25±3.66
Axial diastolic phase	412.13±111.04	34.90±11.27	13.25±6.05	9.76±4.83
cMPR	420.66±113.56	32.25±12.62	14.38±5.60	10.62±4.51

Data expressed as mean ± standard deviation. CCTA, coronary computed tomography angiography; SNR, signal-to-noise ratio; CNR, contrast-to-noise ratio; LAD, left anterior descending artery; cMPR, curved multi planar reformation; LCx, left circumflex artery; RCA, right coronary artery; LM, left main artery.

Coincidentally, both RCA on cMPR image and LM on axial images at systolic phase possessed same quantitative image quality in which there were significant differences in SNR and CNR between males and females (SNR: 12.01±6.43 for males *vs*. 9.22±3.38 for females, P=0.04; CNR: 9.07±5.25 for males *vs*. 6.59±2.88 for females, P=0.03), although no significant differences were observed for both signal intensity and noise (P=0.22 and 0.67, respectively).

On comparing quantitative image quality between 100 and 120 kVp scan protocol, all coronary arteries in all types of images showed a significantly higher signal intensity in 100 kVp scan protocol as compared to 120 kVp protocol (*Figure 2*, P<0.001).

Figures 3,4 show the comparison of noise and SNR between 100 and 120 kVp scan protocol respectively. Higher noise and SNR were observed with 100 kVp scan protocol, except in LCx on the cMPR image which showed 120 kVp scan protocol produced an image with higher SNR (9.02±3.44 for 100 kVp *vs*. 9.20±3.75 for 120 kVp, P=0.86).

Significant difference in noise between 100 and 120 kVp scanning protocol (P<0.05), lead to non-significant difference in SNR between the two scanning protocols (P>0.05) in LAD on axial images at systolic phase, LCx on axial images at systolic and diastolic phases as well as on cMPR image, RCA on axial images at systolic phase and on cMPR image, and LM on cMPR image.

In contrast, non-significant difference in noise between 100 and 120 kVp scanning protocol (P>0.05), led to significant difference in SNR between two scanning protocols (P<0.05) in LAD on axial images at diastolic phase and on cMPR image as well as LM on axial images at systolic phase.

However, there were two coronary arteries that showed no significant differences in both noise and SNR between two scanning protocols; i.e. RCA on axial images at diastolic phase (noise: 49.25±14.17 for 100 kVp *vs*. 40.74±19.61 for 120 kVp, P=0.07; SNR: 10.61±3.69 for 100 kVp *vs*.

Table 2 Comparison of quantitative image quality between genders

Image quality parameters	Coronary artery	Genders		P value
		Males	Females	
Signal intensity	LAD			
	Axial systolic phase	402.63±104.82	368.81±119.46	0.27
	Axial diastolic phase	419.24±110.18	350.54±127.51	0.04*
	cMPR	418.02±102.13	373.83±122.18	0.15
	LCx			
	Axial systolic phase	405.70±104.92	368.41±112.06	0.21
	Axial diastolic phase	415.05±109.30	366.74±117.95	0.13
	cMPR	425.01±102.67	380.22±119.51	0.15
	RCA			
	Axial systolic phase	418.76±98.91	386.61±124.97	0.29
	Axial diastolic phase	428.63±105.94	401.75±153.10	0.47
	cMPR	453.95±106.69	412.34±140.28	0.22
	LM			
	Axial systolic phase	453.95±106.69	412.34±140.28	0.22
	Axial diastolic phase	428.21±105.47	391.36±116.79	0.23
	cMPR	436.87±107.73	399.71±119.70	0.23
Noise	LAD			
	Axial systolic phase	50.03±19.60	49.43±16.95	0.91
	Axial diastolic phase	45.99±17.22	51.10±14.54	0.25
	cMPR	48.18±20.25	48.09±19.54	0.99
	LCx			
	Axial systolic phase	58.06±20.73	58.32±22.55	0.97
	Axial diastolic phase	62.74±25.80	52.73±21.41	0.13
	cMPR	53.78±26.04	46.65±17.98	0.26
	RCA			
	Axial systolic phase	46.24±16.35	47.95±18.30	0.72
	Axial diastolic phase	45.22±16.02	46.66±18.33	0.76
	cMPR	45.70±21.80	48.08±18.04	0.67
	LM			
	Axial systolic phase	45.70±21.80	48.08±18.04	0.67
	Axial diastolic phase	32.73±10.66	37.70±11.63	0.11
	cMPR	32.25±13.72	32.25±11.32	1.00

Table 2 (*continued*)

Table 2 (*continued*)

Image quality parameters	Coronary artery	Genders		P value
		Males	Females	
SNR	LAD			
	Axial systolic phase	8.73±2.87	7.90±2.41	0.26
	Axial diastolic phase	10.05±3.80	7.34±3.56	0.01*
	cMPR	9.83±3.71	8.52±3.14	0.17
	LCx			
	Axial systolic phase	7.67±2.78	6.84±2.16	0.24
	Axial diastolic phase	7.54±3.05	7.96±4.05	0.67
	cMPR	9.19±3.77	8.97±3.28	0.82
	RCA			
	Axial systolic phase	9.84±3.21	8.68±3.00	0.18
	Axial diastolic phase	10.36±4.04	9.26±3.74	0.31
	cMPR	12.01±6.43	9.22±3.38	0.04*
	LM			
	Axial systolic phase	12.01±6.43	9.22±3.38	0.04*
	Axial diastolic phase	14.58±6.27	11.53±5.39	0.06
	cMPR	15.18±5.87	13.35±5.15	0.23
CNR	LAD			
	Axial systolic phase	6.37±2.42	5.47±1.94	0.14
	Axial diastolic phase	7.41±3.08	5.03±2.98	0.01*
	cMPR	7.26±2.88	6.01±2.71	0.11
	LCx			
	Axial systolic phase	5.55±2.09	4.72±1.69	0.12
	Axial diastolic phase	5.50±2.34	5.58±3.31	0.92
	cMPR	6.74±2.87	6.34±2.71	0.60
	RCA			
	Axial systolic phase	7.25±2.45	6.09±2.30	0.08
	Axial diastolic phase	7.65±3.07	6.58±3.15	0.21
	cMPR	9.07±5.25	6.59±2.88	0.03*
	LM			
	Axial systolic phase	9.07±5.25	6.59±2.88	0.03*
	Axial diastolic phase	10.87±4.98	8.33±4.32	0.05
	cMPR	11.32±4.52	9.72±4.42	0.19

Data expressed as mean ± standard deviation. *, indicates significant difference (P<0.05); LAD, left anterior descending artery; LCx, left circumflex artery; RCA, right coronary artery; LM, left main artery.

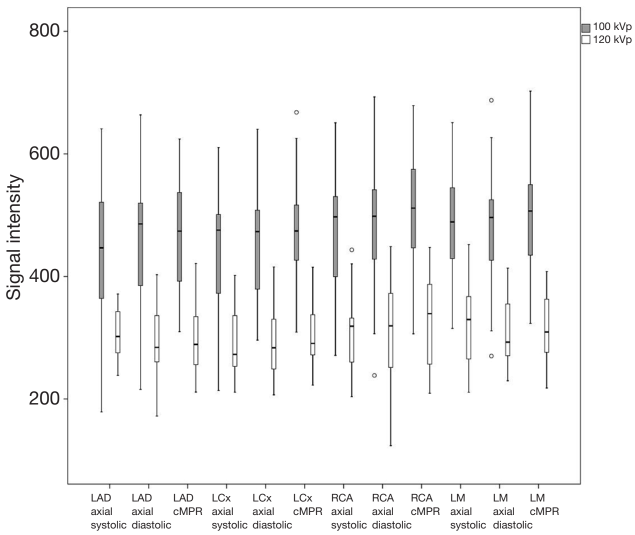

Figure 2 Box plot shows the mean signal intensity for each coronary artery on each type of images with 100 and 120 kVp scan protocol. The box indicates the first to third quartiles, with the line in the box indicating median quartile, and whiskers indicate the minimum and maximum values. Apparently, 100 kVp scan protocol produced CCTA images with higher signal intensity compared with 120 kVp scan protocol. CCTA, coronary computed tomography angiography; LM, left main artery; cMPR, curved multi planar reformation; RCA, right coronary artery; LCx, left circumflex artery; LAD, left anterior descending artery.

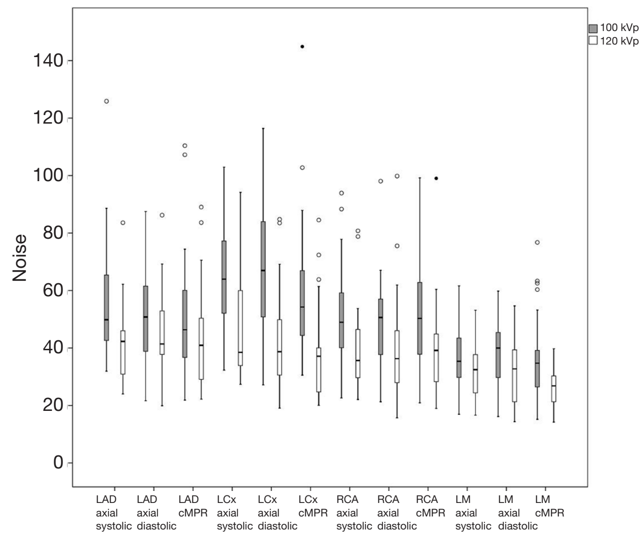

Figure 3 Box plot shows the mean noise for each coronary artery on each type of images with 100 and 120 kVp scan protocol. The box indicates the first to third quartiles, with the line in the box indicating median quartile, and whiskers indicate the minimum and maximum values. It shows that higher noise was observed on CCTA images with 100 kVp scan protocol, compared with 120 kVp scan protocol. CCTA, coronary computed tomography angiography; LM, left main artery; cMPR, curved multi planar reformation; RCA, right coronary artery; LCx, left circumflex artery; LAD, left anterior descending artery.

8.79±4.07 for 120 kVp, P=0.09) and LM on axial images at diastolic phase (noise: 36.86±10.85 for 100 kVp *vs.* 31.95±11.49 for 120 kVp, P=0.12; SNR: 14.58±6.19 for 100 kVp *vs.* 11.27±5.36 for 120 kVp, P=0.05).

Other than LCx, a significant difference in CNR between two scanning protocols was observed in all coronary arteries in all types of images (P<0.05) as presented in *Figure 5*. A 100 kVp scan protocol produced an image with higher CNR compared with 120 kVp scan protocol. Non-significant difference in CNR was observed in LCx on axial images at systolic phase (5.60±2.11 for 100 kVp *vs.* 4.53±1.51 for 120 kVp, P=0.05), axial images at diastolic phase (5.89±3.18 for 100 kVp *vs.* 4.98±1.96 for 120 kVp, P=0.25) and cMPR image (6.75±2.82 for 100 kVp *vs.* 6.27±2.77 for 120 kVp, P=0.54).

Discussion

In order to improve diagnostic accuracy of CCTA, interpreters must review three dimensional displays of CCTA interactively on 3D workstations, including trans-axial two-dimensional images ("raw data") and post-processing images i.e., multiplanar reformation (MPR), maximum intensity projection (MIP), cMPR and volume rendering technique (VRT) reconstructions to have a better understanding of the complex coronary artery anatomy and abnormalities (21,22).

In our study, we quantified objective image quality of axial images at systolic and diastolic phase as well as cMPR images only as both axial images and cMPR images fully retained the information about the HU values. Unlike MIP technique as an example, post-processing is done based on thresholding of HU in a single voxel; this may lead to volume averaging artifacts if that particular voxel only represents part of the anatomy of interest (23). Besides, axial images with both systolic phase and diastolic phase involved as optimal reconstruction window would differ with the heart rate of the patient (24).

Quantitatively, image quality can be presented in a physical quantity such as resolution, contrast, noise and other parameters with the use of software automatically

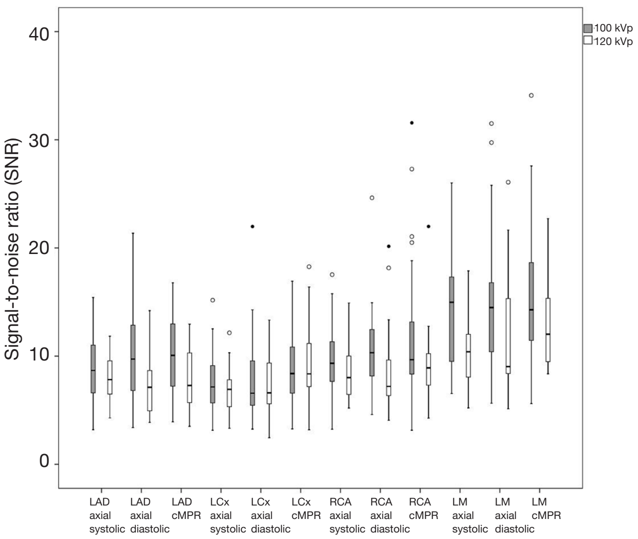

Figure 4 Box plot shows the mean SNR for each coronary artery on each type of images with 100 and 120 kVp scan protocol. The box indicates the first to third quartiles, with the line in the box indicating median quartile, and whiskers indicate the minimum and maximum values. It shows that 100 kVp scan protocol resulted in CCTA images with higher SNR in all coronary arteries on all types of images, except in LCx on cMPR images which showed slightly higher SNR with 120 kVp scan protocol. SNR, signal-to-noise ratio; CCTA, coronary computed tomography angiography; LM, left main artery; cMPR, curved multi planar reformation; RCA, right coronary artery; LCx, left circumflex artery; LAD, left anterior descending artery.

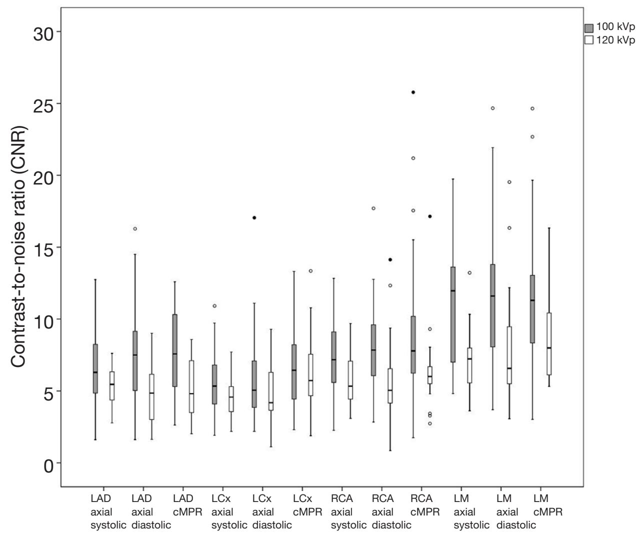

Figure 5 Box plot shows the mean CNR for each coronary artery on each type of images with 100 and 120 kVp scan protocol. The box indicates the first to third quartiles, with the line in the box indicating median quartile, and whiskers indicate the minimum and maximum values. It shows 100 kVp scan protocol leaded to a higher CNR on CCTA images compared with 120 kVp scan protocol. CNR, contrast-to-noise ratio; CCTA, coronary computed tomography angiography.

(25,26). According to Heyer *et al*. (27), they claimed that SNR and CNR would be the best physical parameters to judge image quality quantitatively. In spite of that, CNR is the most practicable physical parameter to depict image quality of CT system (28).

With reference to Karaca *et al*. (29) who classified the CNR into different image quality grade, i.e., CNR >8, high image quality; 4–8, moderate image quality; and <4, poor image quality, LAD, LCx, and RCA have moderate image quality, while LM has high image quality. This result was mainly due to the differences in relative anatomical positions of coronary arteries, in which location of LM is relatively more proximal compared to other coronary arteries. Yang *et al*. (30) also found out that proximal segment of coronary arteries has higher CNR over the distal segment of coronary arteries.

Moreover, ROI plays a crucial role in the quantification of objective image quality. It is an area defined by the user and is usually the first step in making any measurements. Therefore, placement of ROI is crucial in obtaining accurate measurements. Owing to the largest area of ROIs placed for quantification of objective image quality for coronary artery, the averaged CT numbers measured within that particular ROI would be more accurate compared to an ROI that only comprised of part of the anatomy of interest or CT numbers of a single pixel (31). Other than that, the ROIs used were large enough for adequate pixel sampling, and also small enough to reduce the effect of non-uniformity of CT numbers as the measurements taken were limited to coronary artery lumen while avoiding coronary artery wall (32).

Besides, the size of ROIs used for quantification of objective image quality for coronary artery and the cardiac wall is comparable. This allows fair determination of CNR as different size of ROI would affect the number of pixels included, which in turn, affects the value of CT numbers and noise measured (32).

In this study, we observed that 100 kVp scan protocol was associated with an increase in all quantitative image quality parameters comprehensively, compared to 120 kVp scan protocol. These findings correspond to work by Bischoff *et al*. (5), which showed an increase in signal intensity, noise, SNR, and CNR with 100 kVp scan protocol.

The increase in signal intensity could be explained by an increase in photoelectric effect, which is proportional to the atomic number (Z) and inversely proportional to the photon energy (33). With the application of low tube voltage scan protocol, the enhancement of coronary artery is increased due to the contrast medium, which contains iodine with a relatively high atomic number (Z=53), which in turn enhance the X-ray attenuation. Therefore, a reduction in tube voltage leads to an increase in attenuation by the iodinated contrast medium due to the dominance of the photoelectric event (34). As there is a better enhancement of coronary arteries by using 100 kVp scan protocol, it is possible to reduce the volume of contrast medium (34). Also, contrast medium with lower iodine content could be used as there were no differences in image quality as reported by Honoris *et al*. (35).

Meanwhile, the increase in image noise is mainly caused by the depletion of X-rays that reach the detectors at low tube voltage. This phenomenon occurred due to a reduction in X-ray intensity because of a decrease in tube voltage as X-ray intensity is proportional to the square of the tube voltage. Besides, the X-rays have weaker transmission strength, and there is a greater attenuation of the low energy X-ray by the filter in the CT scanner (36). This would be a major pitfall in reducing tube voltage, which can lead to grainy images that could affect diagnostic accuracy consequently.

Furthermore, an increase in signal intensity and noise resulted in an increase in SNR and CNR in our study. However, Hausleiter *et al*. (6) reported a reduction in SNR and CNR due to the concomitant increase in image noise with signal intensity. This is not demonstrated in our study as the increase in signal intensity outweighed the increase in image noise. Thus, 100 kVp scan protocol showed higher SNR and CNR compared to 120 kVp scan protocol.

Although we could have assumed that an individual who with BMI of 30 kg/m^2 or above have excess fat mass, BMI does not distinguish between the fat and muscle compositions in the chest. Fat and muscle distributions could be different in patients with the same BMI value (37). Although genders did not show any significant changes in image quality, previous studies conducted with DSCT have shown that the effective radiation dose estimated in females is significantly higher (30% to 40%) than in male patients because of the size thickness on the chest region (38-40). However, the breast tissue is radiosensitive and keeping the radiation dose to the breast at the minimum level is of paramount importance (38).

There are some limitations in this study. ROIs were placed randomly along the coronary arteries where the best image quality is opined. This does not allow the comparison of quantitative image quality of axial images between systolic phase and diastolic phase because ROIs were not placed at the exactly same segment of the coronary artery for both phases as different coronary arteries would have its best image quality at different phases of reconstructions (24). Besides, our study did not take into consideration of other factors that may affect the image quality of CCTA, especially heart rate, and variability in heart rate.

Conclusions

This study showed that there is no significant difference in image quality of CCTA between genders. Besides, 100 kVp tube voltage scan protocol produce superior quantitative image quality of CCTA compared to 120 kVp tube voltage scan voltage; thus, 100 kVp scan protocol is highly recommended for patient whoever is compatible.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: This study was approved by the institutional ethics committee (IJNEC/05/2013) (01) and written informed consent was obtained from all patients.

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