Comparison of Image Quality of Coronary CT Angiography between 16 and 64 Slices MDCT

Thanonchai Siriapisith MD*,
Jitladda Wasinrat MD*

** Department of Radiology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok*

Objective: *To compare the image quality and visibility of coronary arteries that were performed by 16 slices and 64 slices multidetector row CT (MDCT).*
Study design: *Descriptive analysis.*
Material and Method: *Twenty-eight patients suspected of hearing coronary artery disease had noninvasive coronary CT angiography performed by 16 slices MDCT and 64 slices MDCT. Data were retrospectively analyzed and reviewed by two radiologists. Image quality was assessed by using a grading scale from excellent (4) to non-assessable (0) and the rate of displayed coronary branches was calculated.*
Results: *Four hundred twenty coronary CT angiography segments in 28 patients were evaluated.*
Conclusion: *Coronary CT angiography using 64 slices multi-detector row CT provides a significantly higher image quality of coronary arteries and their branches compared with 16 slices multi-detector row CT.*

Keywords: *Coronary artery, CT angiography, Multidetector row CT, Image quality, Cardiac imaging*

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Myocardial ischemia and myocardial infarction are leading causes of death in Thailand and worldwide[1,2] that result from stenosis or occlusion of coronary arteries supplied myocardium. Clinical diagnosis of coronary arterial disease requires history taking, symptoms, signs, electrocardiogram, and laboratory findings. Computed tomography (CT) has become a clinically important noninvasive diagnostic technique in cardiac gating[1-15]. The accurate imaging needs for therapeutic planning such as percutaneous coronary intervention and coronary arterial bypass graft.

The gold standard for studying coronary images is conventional coronary angiography by percutaneous catheter insertion with contrast medium injection via femoral or axillary arteries passing into the thoracic aorta and placed at origin of coronary arteries. The conventional coronary angiography is an invasive technique for coronary imaging that requires experienced medical staff. Complications may occur during the procedure. The cardiac magnetic resonance imaging has many advantages such as non-radiation, non contrast technique, cardiac function, contractility, perfusion, and viability[2]. However, the disadvantages are its high cost, the non-availablility at many hospitals, the long examination time and the non-visualization of calcium.

The current development of multi-detector row CT (MDCT) is becoming available for coronary imaging. It can be done with cardiac triggering and temporal resolution less than 400 milliseconds. The advantages of MDCT for coronary images are faster study and higher temporal resolution. The imaging quality is enough for the analysis of small vessels as well as 1.5 millimeters vessels [2]. Two recent models of multi-detector row CT (MDCT) have been used; the 16 and 64 slices MDCT. The 64 slices MDCT has improvement of temporal resolution and shorter scanning time compared with the 16 slices MDCT.

The purpose of the present study was to compare image quality and visualization of coronary arteries that was performed by 16 and 64 slices MDCT in the same patient.

Correspondence to : Siriapisith T, Department of Radiology, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand. E-mail: sitsa@mahidol.ac.th

Material and Method

Twenty-eight patients suspected of having coronary artery disease had noninvasive coronary CT angiography performed in Siriraj Hospital by 16 slices MDCT between September 2003 and October 2005 and 64 slices MDCT between October 2005 and March 2007. The 28 patients (17 Men and 11 women) who had consecutively undergone both 16 and 64 multi-detector row CT were retrospectively reviewed. Patients with cardiac arrthymia, irregular heartbeats, heartbeat faster than 80 bpm, and previous coronary artery bypass graft (CABG) were excluded from the present study.

The CT examinations with 16 slices multi-detector row CT scanner (Lightspeed CT; GE medical systems) were performed by following the scanning protocol: 16 x 0.625 mm collimation (simultaneous acquisition of sixteen 0.625 mm-thick sections per rotation); automatically adjusted heart rate according to heart rate; 500 msec rotation time; 120 kV and 440 mA. To calculate the scanning delay, a test bolus 20 ml of contrast material at flow rate 4 ml per second was done. The arrival time at the ascending aorta was calculated by measuring peak CT attenuation at the ascending aorta plus 2 seconds. The contrast injection was 120 ml bolus of nonionic contrast material (350-370 mg of iodine per milliliter) by a single syringe power injector at 300 PSI. The ECG monitoring was simultaneously triggered with CT scan. CT scans at the level of the aortic root just below the carina about 1 cm to the bottom of the heart. The patients were instructed to briefly hyperventilate three times and hold their breath about 20 seconds for scanning. The field of view was as small as possible for the area of the heart.

The CT examinations with 64 slices multi-detector row CT scanner (Lightspeed CT; GE medical systems) were performed by following the scanning protocol: 64 x 0.625 mm collimation (simultaneous acquisition of sixty-four 0.625 mm-thick sections per rotation); automatically adjusted heart rate according to the heart rate; 350 msec rotation time; 120 kV and 700 mA. To calculate the scanning delay, a test bolus of 15 ml of contrast material plus normal saline 15 ml at flow rate 5 ml per second was done. The arrival time at the ascending aorta was calculated by measuring peak CT attenuation at the ascending aorta plus 5 seconds. The contrast injection was 60 ml bolus of nonionic contrast material (350-370 mg of iodine per milliliter) and 30 ml flush normal saline by dual syringe power injector at 300 PSI. The ECG monitoring was simultaneously triggered with the CT scan. CT scans at the level of the aortic root just below the carina about 1 cm to the bottom of the heart. Patients were instructed to briefly hyperventilate three times and hold their breath. The image reconstructions were retrospectively performed at 35%, 45%, 55%, 65%, 75% and 85% of the cardiac cycle[16]. The best image quality in these phases was selected for analysis. The reconstructed section thickness was 0.625 mm, and the image increment was 0.625 mm. The image data from each of these reconstructions were transferred to a computer workstation (Advantage of the workstation; GE medical system). The three-dimensional volume rendered and curved reformatted post-processing was used for image analysis.

Two cardiovascular radiologists with 4 and 2 years experience independently reviewed the three-dimensional volume rendered and curved reformatted images interactively on the workstation. The coronary arteries were divided into 15 segments (Fig. 1, Table 2) according to the standard American Heart Association[17]. Each reader assessed segments 1-3 (right coronary artery), segment 5 (left main coronary artery), segments 6-8 (left anterior descending artery), and segment 11 and 12 (left circumflex artery). The image quality was descriptively analyzed in five grades: 0-cannot be detected, 1-poor or cannot be assessed; 2-fair (moderate blurring and mild artifact); 3-good (slightly blurring coronary arterial wall); 4-excellent (no artifacts, good visualization). For segments with inter-observer disagreement, consensus was reached after the reviewers re-read the scans.

Statistical analysis

The patient's characteristics and scan parameter were compared by using the paired t-test. The

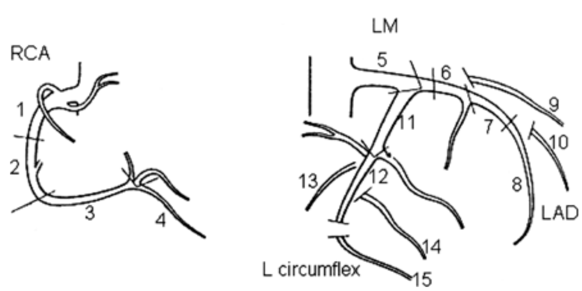

Fig. 1 Diagram of coronary anatomy divided into 15 segments according to american heart association (RCA: right coronary artery, LM: left main coronary artery, LAD: left anterior descending artery, L circumflex or LCX: left circumflex coronary artery

Table 1. Characteristic of patients performing coronary CT angiography in 16 slices and 64 slices MDCT

	16 slices MDCT	64 slices MDCT	p-value
Number of patient	28	28	
Age (years)	64.4 ± 10.7	66.0 ± 10.7	<0.6
Sex (male : female)	17:11	17:11	
Heart rate (beats/minute)	62.2 ± 9.2	61.5 ± 8.13	<0.8321
Detector model (slices x mm)	16 x 0.625, 16 x 1.25 for LIMA graft	64 x 0.625	
Thickness	0.625 mm, 1.25 mm for LIMA graft	0.625 mm	
Breath holding (seconds)	18.38 ± 2.20	6.92 ± 2.00	<0.001
kV	120	120	
mAs	191.07 ± 18.35	254.93 ± 11.23	<0.001
Temporal resolution (msec)	330	230	<0.001
Amount of contrast (ml)	140 ml contrast medium in single syringe	75 ml contrast medium + 45 ml NSS in dual syringe	<0.001
Rate of contrast injection	4 ml/sec	5 ml/sec	

Wilcoxon signed ranks test for paired data was used to test for differences in image quality at 16 slices and 64 slices coronary CT angiography. All of the data are given as mean ± standard deviation. A p-value of < 0.05 was described as statistically significant.

The level of agreement between the readers was determined by using Kappa values, which were measures of inter-observer concordance. Values of less than 0.40 were indicative of poor concordance, values of 0.40-0.60 of moderate concordance, values of 0.60-0.80 of good concordance, and values greater than 0.80 of very good agreement.

Table 2. Duration between 16 and 64 slices MDCT coronary CT angiography in same patient

	Duration between two studies (day)
Average	612.98
SD	252
Min	100
Max	1,175

Results

The 28 patients included in this study were (male 17:female 11), age ranged from 42 to 93 years (mean 64.4 ± 10.7 years). The average time between the two studies was about 613 ± 252 days. Six patients were requested for assessment of coronary bypass graft. Mean patient heart rate was 62.2 ± 9.2 beats per minute (bpm) (range 45-85 bpm). The heart rates between the two studies were also not statistically significant different (16 slices: 64.4pbm; 64 slices: 66 bpm).

Two radiologists evaluated the coronary CT angiography of 420 segments in 28 patients. The 420 segments were divided into proximal 168 branches and distal 252 branches. For segments with inter-observer disagreement (119 segments for 16 slices MDCT and 166 segments for 64 slices MDCT), consensus was reached after the reviewers re-read the scans. The consensus results for both radiologists are listed in the Table 1.

Overall image quality of coronary CT angiographic studies at 64 slices MDCT was significantly improved in comparison to 16 slices MDCT (2.24 ± 1.36 vs. 1.42 ± 1.12, p < 0.001). The number of segments with excellent (grade 4: 64 slices n = 116/420; 16 slices n = 13/420) and good (grade 3: 64 slices n = 105/420; 16 slices n = 68/420) image quality was significantly improved (p < 0.01) for 64 slices MDCT compared to imaging at 16 slices MDCT, Fig. 2. The non-assessable segment at 64 slices MDCT was also significantly decreased in comparison to 16 slices MDCT (64 slices n = 58/420; 16 slices n = 106/420, p < 0.01). The detailed scoring of image quality is given in Table 3-6.

The average total scan time in 64 slices MDCT was significantly decreased about 2.7 times lower than 16 slices MDCT (64 slices: 6.92 ± 2.0 seconds; 16 slices: 18.38 ± 2.2 seconds, p < 0.001). The total amount of contrast in 64 slices MDCT was also significantly smaller than 16 slices MDCT (64 slices: 75ml; 16 slices

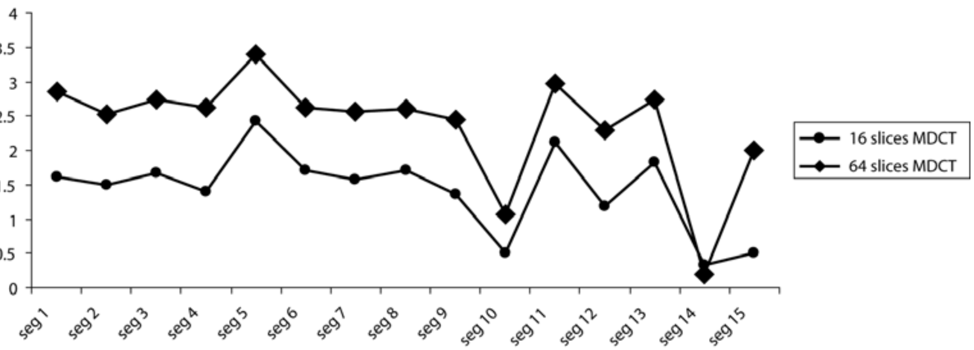

Fig. 2 Comparison of average image quality for each coronary segment (segment 1 to segment 15) in 16 slices and 64 slices coronary CT images, the comparison shows that image quality in 64 is better than 16 slices coronary CT images

Table 3. Correlation between image quality and segment of coronary artery in 16 slices MDCT: the proximal segment is defined as proximal RCA, mid RCA, left main, proximal LAD, mid LAD, proximal LCX. The distal segment is defined as distal RCA, posterior descending branch, distal LAD, 1st diagonal branch, 2nd diagonal branch, distal LCX, 1st obtuse marginal branch, 2nd obtuse marginal branch

	Image quality for 16 slices MDCT					
Segment	0-N/A	1-poor	2-fair	3-good	4-excellent	Total
Proximal	12	57	55	37	7	168
Distal	94	66	55	31	6	252
	106 (25.2%)	123 (29.3%)	110 (26.2%)	68 (16.2%)	13 (3.1%)	420

Table 4. Correlation between image quality and segment of coronary artery in 64 slices MDCT: the proximal segment is defined as proximal RCA, mid RCA, left main, proximal LAD, mid LAD, proximal LCX. The distal segment is defined as distal RCA, posterior descending branch, distal LAD, 1st diagonal branch, 2nd diagonal branch, distal LCX, 1st obtuse marginal branch, 2nd obtuse marginal branch

	Image quality for 64 slices MDCT					
Segment	0-N/A	1-poor	2-fair	3-good	4-excellent	Total
Proximal	1	19	44	44	60	168
Distal	58	26	52	61	56	252
	58 (13.8%)	45 (10.7%)	96 (22.9%)	105 (25%)	116 (27.6%)	420

Table 5. Inter-observer agreement between two readers according to overall segments of 16 and 64 slices MDCT

	16 slices MDCT	64 slices MDCT
K coefficient	0.81	0.85

140ml, $p < 0.001$). The average heart rate during scanning was not significantly different (64 slices: 61.5 $\pm$ 8.13 bpm; 16 slices: 62.2 $\pm$ 9.2 pbm).

The higher tube current was needed for 64 slices MDCT (728.36 $\pm$ 32.08 mA) than 16 slices MDCT (382.14 $\pm$ 36.70 mA) that is significantly higher effective tube current for 64 slices MDCT (64 slices:

Table 6. Comparison average image quality of coronary arteries between 16 and 64 slices MDCT

Segment	16 slices MDCT	64 slices MDCT	Wilcoxon test
1	1.61	2.89	$p \leq 0.001$
2	1.5	2.54	$p \leq 0.003$
3	1.68	2.75	$p \leq 0.001$
4	1.39	2.64	$p \leq 0.001$
5	2.43	3.43	$p \leq 0.001$
6	1.71	2.64	$p \leq 0.001$
7	1.57	2.61	$p \leq 0.001$
8	1.71	2.64	$p \leq 0.001$
9	1.36	2.5	$p \leq 0.001$
10	0.52	1.18	$p \leq 0.207$
11	2.11	3	$p \leq 0.002$
12	1.18	2.36	$p \leq 0.002$
13	1.82	2.75	$p \leq 0.001$
14	0.33	0.32	$p \leq 0.857$
15	0.5	2.04	$p \leq 0.001$

254.93 ± 11.23 mAs; 16 slices: 191.07 ± 18.35 mAs, $p < 0.001$).

Discussion

Multidector CT became an important role for depiction of morphological and functional analysis of the heart. The 16 slices MDCT was a famous tool for the diagnosis of coronary artery stenosis which had many advantages such as less invasive, fewer complications, lower cost and shorter study time.

The present study shows that more slices and faster scanner in 64 slices MDCT technically improves temporal resolution (16 slices: 350 milliseconds; 64 slices: 230 milliseconds) and achieves statistically higher overall image quality of coronary CT angiography compared to imaging in 16 slices MDCT (Fig. 2-4). Subgroup analysis for each segment of coronary arteries found statistical improvement ($p < 0.01$) of image quality in 64 slices in comparison to 16 slices CT images except 10th segment (2nd diagonal branch of anterior descending artery). The image quality of this 10th segment in 64 slices CT images was worse than 16 slices CT images because in most of the patients the 2nd diagonal branch of the anterior descending artery could not be detected in 16 slices and 64 slices (9 patients in 16 and 12 patients in 64 slices CT images). The zero value for non-assessability this segment produces no statistical significance.

Many factors that may interfere with image quality between 16 and 64 slices CT images that are technically contrasted variable such as spatial resolution, slice thickness, and reconstruction techniques. The increased amount of mAs for coronary CT angiography (64 slices: 254.93 ± 11.23 mAs; 16 slices: 191.07 ± 18.35 mAs, $p < 0.001$) could be one important factor for improvement of image quality that was technically decreased imaging noise. Cheng Hong et al[18]. reported image noise to decrease as tube current increased. The

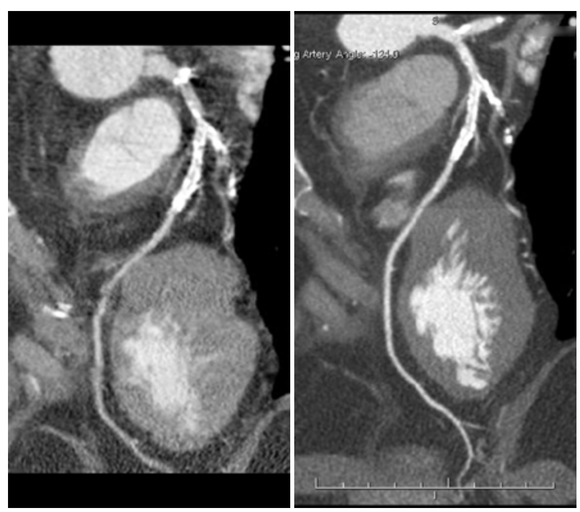

Fig. 3 Image quality comparison between 16 and 64 slices MDCT: Patient requested for follow up coronary stent performed 64 slices coronary CTA and 16 slices coronary CTA. The curved multiplanar reformations of left main and left anterior descending arteries show significantly improvement of image quality in 64 slices coronary CT image (right) as compared with 16 slices coronary CT image (left)

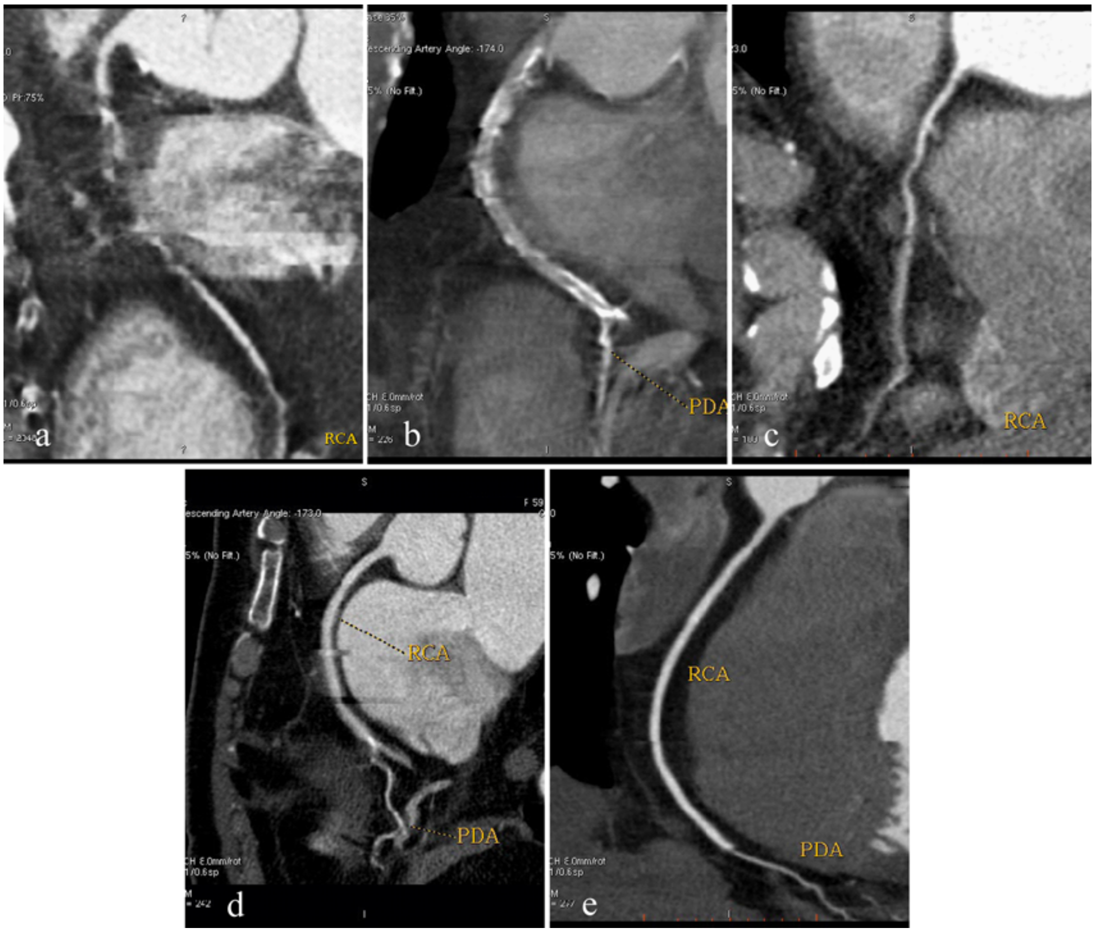

Fig. 4 Curved multiplanar reformations of 16 and 64 slices CT images of RCA in five different patients illustrate use of semiquantitative five-point image quality score

(a) Image shows in non-evaluative (score0) for proximal part of the RCA

(b) Image shows severe artifact (score 1) with discontinuity of the RCA

(c) Image show moderate motion artifacts (score 2) ih the middle segments of the RCA, with moderate blurring of the vessel outline

(d) Image shows mild motion artifact (score 3) that cause mild blurring of the RCA wall

(e) Image shows excellent image quality of the RCA without motion artifact

image quality improvement in 64 slices MDCT was technically because of improved temporal, spatial resolution and higher tube current[19]. The temporal resolution in the present study 64 slices MDCT was 230 msec that was slightly higher than recent studies[12,19].

The present study was similar to recent studies for evaluation of image quality of coronary artery segment on 64 slices MDCT. Dewey et al, Hamoir et al[20,21] showed better image quality of 64 slices than 16 slices in a retrospective analysis of the same patients undergoing CT coronary angiography. The other studies[10,22,23] showed also higher contrast-to-noise ratios in 64 slices MDCT. Hausleiter et al[24] found a decreased amount of poor image quality coronary segments in 64 slices MDCT. Harpreet et al[19] in independently reviewed image quality of 64 slices MDCT found also good assessable coronary artery segments in 89%.

The limitation in the present study was retrospective study. The duration between the two studies took a very long time (612.98 ± 252 days, range from 100 to 1,175 days), about 2 years. Therefore, the status of coronary artery may be changed, such as an increased amount of calcium and progression of coronary stenosis. Another limitation was the changing condition of coronary arteries in some patients such as post percutaneous balloon angiography, stent placement, and surgical bypass graft.

Conclusion

Current development of 64 slices MDCT allows the improvement of image quality of coronary CT angiography in comparison with 16 slices MDCT.

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การศึกษาเปรียบเทียบคุณภาพของภาพที่ได้จากการตรวจหลอดเลือดหัวใจด้วยเอกซเรย์คอมพิวเตอร์ชนิด 16 และ 64 หัววัด

ทนงชัย สิริอภิสิทธิ์, จิตรลัดดา วะศินรัตน์

วัตถุประสงค์: *เพื่อศึกษาคุณภาพของภาพและความสามารถในการมองเห็นหลอดเลือดหัวใจในการตรวจด้วยเครื่องเอกซเรย์คอมพิวเตอร์ความเร็วสูงชนิด 16 และ 64 หัววัด*

รูปแบบการศึกษา: *แบบพรรณนา*

วัสดุและวิธีการ: *ผู้ป่วยจำนวน 28 รายที่สงสัยว่าจะมีโรคหลอดเลือดหัวใจได้รับการตรวจด้วยเครื่องเอกซเรย์คอมพิวเตอร์ความเร็วสูงชนิด 16 และ 64 หัววัด ตามลำดับ ข้อมูลที่ได้นำมาศึกษาด้วยการศึกษาแบบย้อนหลังโดยรังสีแพทย์ 2 ท่าน คุณภาพของภาพที่ได้จากการตรวจแบ่งออกเป็น 5 ระดับ ตั้งแต่คุณภาพของภาพดีเยี่ยม (4) จนถึงไม่สามารถแปลผลได้ (0) และศึกษาอัตราการมองเห็นหลอดเลือดแขนงของหัวใจ*

ผลการศึกษา: *หลอดเลือดหัวใจจำนวน 420 segments จากจำนวนผู้ป่วย 28 รายที่ได้รับการตรวจด้วย coronary CT angiography*

สรุป: *การตรวจหลอดเลือดหัวใจด้วยเครื่องเอกซเรย์คอมพิวเตอร์ชนิด 64 หัววัด ให้คุณภาพของภาพหลอดเลือดหัวใจและแขนงดีกว่าอย่างมีนัยสำคัญทางสถิติเมื่อเทียบกับการตรวจด้วยเครื่องเอกซเรย์คอมพิวเตอร์ชนิด 16 หัววัด*