Imaging of coronary atherosclerosis and vulnerable plaque

Velzen, J.E. van

CHAPTER 11

Diagnostic Accuracy of 320-Row Multidetector Computed Tomography Coronary Angiography in the Non-Invasive Evaluation of Significant Coronary Artery Disease

Fleur R. de Graaf, Joanne D. Schuijf, Joëlla E. van Velzen, Lucia J. Kroft, Albert de Roos, Johannes H.C. Reiber, Eric Boersma, Martin J. Schalij, Fabrizio Spano,, J. Wouter Jukema, Ernst E. van der Wall, Jeroen J. Bax

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ABSTRACT

Background: Multidetector computed tomography coronary angiography (CTA) has emerged as a feasible imaging modality for non-invasive assessment of coronary artery disease (CAD). Recently, 320-row CTA systems were introduced, with 16-cm anatomical coverage, allowing image acquisition of the entire heart within a single heart beat. The aim of the present study was to assess the diagnostic accuracy of 320-row CTA in patients with known or suspected CAD.

Methods: A total of 64 patients (34 male, mean age 61 ± 16 years) underwent CTA and invasive coronary angiography. All CTA scans were evaluated for the presence of obstructive coronary stenosis by a blinded expert, and results were compared to quantitative coronary angiography (QCA).

Results: Four patients were excluded from initial analysis due to non-diagnostic image quality. Sensitivity, specificity, positive and negative predictive values to detect ≥ 50% luminal narrowing on a patient basis were 100%, 88%, 92% and 100%, respectively. Moreover, sensitivity, specificity, positive and negative predictive values to detect ≥ 70% luminal narrowing on a patient basis were 94%, 95%, 88% and 98%, respectively. With inclusion of non-diagnostic imaging studies, sensitivity, specificity, positive and negative predictive values to detect ≥ 50% luminal narrowing on a patient basis were 100%, 81%, 88% and 100%, respectively.

Conclusion: The current study shows that 320-row CTA allows accurate non-invasive assessment of significant CAD.

INTRODUCTION

Cardiovascular disease is the leading cause of morbidity and mortality in the Western world. Early detection of coronary artery disease (CAD) is of vital importance as timely treatment may significantly reduce morbidity and mortality. Although invasive coronary angiography remains the standard of reference for the evaluation of CAD, multidetector computed tomography coronary angiography (CTA) has recently emerged as a robust imaging modality for the non-invasive evaluation of CAD.[1] With sub-millimeter spatial resolution this technique allows detailed visualization of luminal narrowing as well as atherosclerotic changes within the coronary vessel wall. Advances in CTA technology have led to continuous improvements in image quality as well as reduction in radiation dose and contrast material. Recently, 320-row CTA systems were introduced, with enhanced cranio-caudal volume coverage as compared to 64-row systems. With 16-cm anatomical coverage (0.5 mm x 320 detectors), this new generation of CTA scanners allows image acquisition of the entire heart within a single gantry rotation and heart beat. Accordingly, wide volume CTA, in combination with prospective image acquisition, allows for a marked decrease in scan time and time of breath-hold, resulting in decreased radiation dose and contrast material as compared to retrospective helical imaging requiring multiple heart beats. In addition, improved temporal resolution and scan time result in an overall reduction of cardiac motion artifacts' and eliminate the problem of stair-step artifacts', observed during step-and-shoot acquisition techniques and helical imaging.[2-5]

The diagnostic accuracy of 320-row CTA in the evaluation of significant coronary artery stenosis has not been previously reported. Therefore, the purpose of the current study was to evaluate the diagnostic accuracy of 320-row CTA in the identification of significant CAD, compared to invasive coronary angiography as the standard of reference.

METHODS

Patient population

The study population consisted of 64 patients (34 male, mean age 61 ± 16 years) who were scheduled for invasive coronary angiography and in whom also CTA was performed. Referral for CTA of patients scheduled for conventional coronary angiography was based on patient eligibility and availability of the CT scanner. Exclusion criteria for CTA examination were: 1) (supra)ventricular arrhythmias, 2) renal failure (glomerular filtration rate < 30 ml/min), 3) known allergy to iodine contrast material, 4) severe claustrophobia, 5) pregnancy. Diagnostic invasive coronary angiography served as the standard of reference. Patients with total calcium score > 1000 or previous coronary artery bypass grafting (CABG) were excluded from the study. Based on these exclusion criteria, 2 patients with atrial fibrillation were excluded from CTA. Furthermore, 8 patients with previous CABG and 16 patients with a total calcium score exceeding 1000 were excluded from the study. The mean interval between invasive coronary angiography and CTA was 23 ± 32 days. No interventions or changes in the clinical

condition of the patients occurred between the examinations. Table 1 presents an overview of the main clinical characteristics of the study population. The study was conducted in accordance with the principles of the Declaration of Helsinki. All patients gave written informed consent to the study protocol, which was approved by the local Ethics Committee.

Table 1. Clinical characteristics of the study population

Number of patients	64
Age (yrs)	61 ± 16
Men / women	34 / 30
Average calcium score (Agatston)	184 ± 223
BMI * (kg/m²)	26 ± 3
Family history of CAD †	27 (42%)
Diabetes	13 (20%)
Hypertension	41 (64%)
Hypercholesterolemia	29 (45%)
Current smoker	12 (19%)
Previous myocardial infarction	15 (23%)
Anterior wall	2 (3%)
Inferior wall	10 (15%)
Posterior wall	3 (5%)
Previous percutaneous coronary intervention	18 (28%)
Number of coronary arteries with ≥ 50% luminal narrowing on angiographic examination	
None	27 (42%)
1	25 (39%)
2	9 (14%)
3	3 (5%)

* BMI, Body Mass Index; † CAD, coronary artery disease

CTA data acquisition

CTA studies were performed using a 320-row CTA scanner (Aquilion ONE, Toshiba Medical Systems, Otawara, Japan) with 320 detector rows (each 0.5 mm wide) and a gantry rotation time of 350 ms. Metoprolol was administered orally (50-100 mg depending on heart rate) 1 hour before data acquisition to patients with a heart rate exceeding 65 beats per minute (bpm), unless contraindicated. The entire heart was imaged in a single heart beat, with a maximum of 16 cm cranio-caudal coverage. During the scan, the ECG was registered simultaneously for prospective triggering of the data. The phase window was set at 65-85% of R-R interval in patients with a heart rate ≥ 60 bpm, and 75% of R-R interval in patients with stable heart rate < 60 bpm. In patients requiring LV function measurements, prospective ECG triggered dose modulation was used, scanning an entire cardiac cycle and attaining maximal tube current at 75% (when stable heart rate < 60 bpm) or 65-85% (when heart rate ≥ 60 bpm) of R-R interval. When prospective dose modulation was used,

the tube current outside of the pre-defined interval was 25% of the maximal tube current.

Tube voltage and current were adapted to body mass index (BMI) and thoracic anatomy. Tube voltage was 100 kV (BMI < 23 kg/m²), 120 kV (BMI 23 - 35 kg/m²) or 135 kV (BMI ≥ 35 kg/m²) and maximal tube current was 400-580 mA (depending on body weight and thoracic anatomy). A tri-phasic injection of intra-venous contrast was used and the total amount of non-ionic contrast media (Iomeron 400; Bracco, Milan, Italy) injected into the antecubital vein was 60-80 ml (depending on body weight). First, 50-70 ml of contrast media was administered at a flow rate of 5.0 or 6.0 ml/s, followed by 20 ml of 50% contrast/saline. Subsequently, a saline flush of 25 ml was administered at a flow rate of 3.0 ml/s. In order to synchronize the arrival of the contrast media and the scan, bolus arrival was detected using automated peak enhancement detection in the left ventricle using a threshold of +180 Hounsfield Units. All images were acquired during an inspiratory breath-hold of approximately 5 seconds. An initial data set was reconstructed at 75% of R-R interval, with a slice thickness of 0.50 mm and a reconstruction interval of 0.25 mm. If multiple phases were obtained, additional reconstructions were explored in case of motion artifacts in order to obtain images with the least motion artifacts. For processing and evaluation, images were transferred to a remote workstation with dedicated CTA analysis software (Vitrea FX 1.0, Vital Images, Minnetonka, MN, USA). CTA was performed successfully in all patients without complications. During the CTA examination mean heart rate (± SD) was 60 ± 11 bpm. Radiation dose was quantified with a dose-length product conversion factor of 0.014 mSv/(mGy×cm) as described.[6]

When scanning prospectively, full dose at 75% of R-R interval, estimated mean radiation dose was 3.9 ± 1.3 mSv (range 2.7 - 6.2 mSv). When scanning prospectively, full dose at 65-85% of R-R interval, estimated mean radiation dose was 6.0 ± 3.0 mSv (range 3.1 – 11.8 mSv). The estimated mean radiation dose for prospectively ECG triggered modulated scans was 10.8 ± 2.8 mSv (range 4.5 – 14.2 mSv). The average investigation time for the CTA acquisitions was approximately 20 minutes.

CTA image analysis

CTA image analysis was performed by 2 observers in consensus, experienced in the evaluation of CTA and blinded to the invasive coronary angiography data. First, general information regarding the status and anatomy of the coronary arteries was obtained using three-dimensional volume rendered reconstructions. Subsequently, axial slices were visually examined for the presence of significant narrowing by determining the presence of ≥ 50% and ≥ 70% reduction of luminal diameter as recommended by the SCCT guidelines for the interpretation and reporting of CTA.[7] CTA analysis was assisted by curved multiplanar reconstructions of all vessels. Data was analyzed on a segmental, vessel and patient basis. Coronary anatomy was assessed in a standardized manner by dividing the coronary artery tree into 17 segments according to a modified American Heart Association classification.[8] Each segment was determined interpretable or uninterpretable and evaluated for the presence of ≥ 50% and ≥ 70% stenosis. Subsequently vessel based analysis was performed. In case 1 segment was uninterpretable, an intention to diagnose strategy was

applied. However, if more than 1 segment in a single vessel was deemed uninterpretable, the vessel was considered to be of non-diagnostic image quality. Finally, a patient based analysis was performed using a similar approach. In case 1 vessel was uninterpretable, an intention to diagnose strategy was applied. However, if more than 1 vessel was uninterpretable, the entire scan was considered to be of non-diagnostic image quality. Accordingly, diagnostic image quality, the presence of ≥ 50% and the presence of ≥ 70% stenosis were assessed on a segmental, vessel and patient level. Of note, the presence of restenosis in a stented segment was identified by reduced or complete absence of contrast within the stent as well as reduced or absent runoff of contrast distally to the stented segment.

Invasive coronary angiography analysis

Invasive coronary angiography was performed according to standard techniques. Angiograms were assessed by an experienced observer blinded to the results of CTA. The available coronary segments were identified on the basis of the American Heart Association guidelines. The same segmental model with identical definitions was used for both the invasive coronary angiography and CTA analysis. Subsequently, all segments were visually classified as normal (no atherosclerosis or minor wall irregularities with ≤ 20% luminal narrowing) or abnormal (presence of stenosis with > 20% luminal narrowing). All segments visually scored as abnormal were quantified using a dedicated and validated quantitative coronary angiography (QCA) software package (QAngioXA 6.0, CA-CMS, Medis Medical Imaging Systems, Leiden, The Netherlands). Each segment was evaluated for the presence of significant stenosis by determining the presence of ≥ 50% and ≥ 70% luminal diameter reduction in the angiographic view with most severe luminal narrowing. Obstructive CAD was defined as luminal narrowing of ≥ 50% on QCA analysis.

Statistical analysis

Data were analyzed on segment, vessel and patient basis. Sensitivity, specificity and positive and negative predictive values, including 95% confidence intervals (CI), for the detection of ≥ 50% and ≥ 70% luminal narrowing on invasive coronary angiography were calculated. In an initial analysis, the diagnostic accuracy was determined excluding segments, vessels or patients of non-diagnostic image quality. In a subsequent analysis, non-diagnostic segments, vessels or patients were included in the analysis, and were considered positive (≥ 50% luminal narrowing). In the analysis on a vessel basis, the left main was considered part of the left anterior descending artery (LAD) and the intermediate branch was considered part of the left circumflex artery (LCx). Continuous data were expressed as mean ± standard deviation (SD). Statistical analyses were performed using SPSS software version 16 (SPSS, Inc., Chicago, Illinois). A value of $p < 0.05$ was considered statistically significant and all reported p-values were two-sided. Generalized estimating equation (GEE) method was applied for stenosis evaluation (for both the presence of ≥ 50% and ≥ 70% stenosis) to account for clustering of coronary artery segments within patients. The GEE analyses were performed with proc GENMOD with a binominal distribution for the outcome variable, the link function specified as logit, and patients as separate subjects.

RESULTS

Segment analysis

In a total of 839 segments available for analysis, invasive coronary angiography identified 72 segments containing significant stenosis. However, 12 segments (1%) were uninterpretable as a result of: motion artifacts (n=7), extensive calcifications (n=2), vessel of small diameter (n=2) and blooming artifact due to stent (n=1). Eight uninterpretable segments were located in the right coronary artery (RCA) (segment 1, n=2; segment 2, n=3; segment 3, n=2; segment 4, n=1), two uninterpretable segments were located in the LCx (segment 11, n=1; segment 13, n=1) and two uninterpretable segments were located in the LAD (segment 7, n=1; and segment 8, n=1). In the remaining 827 segments, CTA analysis correctly ruled out significant stenosis in 735 segments. In a total of 62 segments, significant lesions were correctly identified on CTA, while 21 segments deemed non-obstructive on coronary angiography, were incorrectly classified as obstructive by CTA. Consequently, the sensitivity and specificity for the detection of ≥ 50% stenosis on a segment basis were 87% and 97%, respectively, and positive and negative predictive values were 75% and 99% respectively. The diagnostic accuracy for the detection of ≥ 50% luminal narrowing excluding and including non-diagnostic segments, as well as the diagnostic performance for the detection of ≥ 70% luminal narrowing are shown in Tables 2 and 3, respectively. As determined with GEE analyses, the presence of a significant stenosis on CTA was highly predictive for the presence of a significant stenosis on CAG, both for ≥ 50% luminal narrowing (odds ratio (OR) 5.5, 95% CI 4.6 - 6.5) and ≥ 70% luminal narrowing (OR 7.7, 95% CI 5.6 - 9.8).

Table 2. Diagnostic accuracy of 320-row CTA for the detection of ≥ 50% coronary stenosis.

	Segment Analysis	Vessel Analysis	Patient Analysis
Excluding non-diagnostic segments, vessels and patients			
Non-diagnostic	12/839, 1%	2/177, 1%	4/64, 6%
Sensitivity	62/71 (87%, 80%-95%)	48/51 (94%, 88%-100%)	35/35 (100%)
Specificity	735/756 (97%, 96%-98%)	114/124 (92%, 87%-97%)	22/25 (88%, 75%-100%)
PPV	62/83 (75%, 65%-84%)	48/58 (83%, 73%-92%)	35/38 (92%, 84%-100%)
NPV	735/744 (99%, 98%-99.6%)	114/117 (97%, 95%-100%)	22/22 (100%)
Diagnostic Accuracy	797/827 (96%, 95%-98%)	162/175 (93%, 89%-96%)	57/60 (95%, 89%-100%)
Including non-diagnostic segments, vessels and patients			
Sensitivity	63/72 (88%, 80%-95%)	48/51 (94%, 88%-100%)	37/37 (100%)
Specificity	735/767 (96%, 94%-97%)	114/126 (90%, 85%-96%)	22/27 (81%, 67%-96%)
PPV	63/95 (66%, 57%-76%)	48/60 (80%, 70%-90%)	37/42 (88%, 78%-98%)
NPV	735/744 (99%, 98%-99.6%)	114/117 (97%, 95%-100%)	22/22 (100%)
Diagnostic Accuracy	798/839 (95%, 94%-97%)	162/177 (92%, 87%-96%)	59/64 (92%, 86%-99%)

Data are absolute values used to calculate percentages. Data in parenthesis are percentages with 95% confidence intervals. Patients with scans of non-diagnostic image quality were excluded from vessel and segment analysis.

CI, confidence interval; CTA, computed tomography angiography; NPV, negative predictive value; PPV, positive predictive value.

Vessel analysis

In 177 vessels evaluated, a total of 51 significantly obstructed vessels were identified on invasive coronary angiography. In total, 2 vessels (1%) were rendered non-diagnostic on CTA analysis due to motion artefacts in a patient with increased HR during acquisition (RCA, n=1) and small vessel lumen (LCx, n=1). In the remaining 175 vessels, CTA correctly ruled out significant stenosis in 114 vessels. One or more significant lesions were correctly identified by CTA in 48 vessels, whereas CTA overestimated lesion size in 10 vessels. The absence of significant stenosis was incorrectly identified by CTA in only 3 vessels (LAD, n=2; LCx n=1), resulting in a sensitivity and specificity of 94% and 92%, respectively. Positive and negative predictive values were 83% and 97%, respectively. The diagnostic accuracy for the detection of ≥ 50% luminal narrowing excluding and including non-diagnostic vessels, as well as the diagnostic performance for the detection of ≥ 70% luminal narrowing are depicted in Tables 2 and 3.

Table 3. Diagnostic accuracy of 320-row CTA for the detection of ≥ 70% coronary stenosis.

	Segment Analysis	Vessel Analysis	Patient Analysis
Non-diagnostic	12/839, 1%	2/177, 1%	4/64, 6%
Sensitivity	23/24 (96%, 88%-100%)	17/18 (94%, 84%-100%)	15/16 (94%, 82%-100%)
Specificity	795/803 (99%, 98%-99.7%)	153/157 (97%, 95%-99.9%)	42/44 (95%, 89%-100%)
PPV	23/31 (74, 59%-90%)	17/21 (81%, 64%-98%)	15/17 (88%, 73%-100%)
NPV	795/796 (99.9%, 99.6%-100%)	153/154 (99%, 98%-100%)	42/43 (98%, 93%-100%)
Diagnostic Accuracy	818/827 (99%, 98%-99.6%)	170/175 (97%, 95%-99.6%)	57/60 (95%, 89%-100%)

Data are absolute values used to calculate percentages. Data in parenthesis are percentages with 95% confidence intervals. Patients with scans of non-diagnostic image quality were excluded from vessel and segment analysis.
CI, confidence interval; CTA, computed tomography angiography; NPV, negative predictive value; PPV, positive predictive value.

Patient analysis

Out of 64 CTA examinations, four scans (6%) were of non-diagnostic image quality caused by: severe motion artifacts due to extra-systole during image acquisition (n=1) and an unexpected rise in HR during contrast administration (n=1), poor contrast attenuation (n=1) and heavy calcifications (n=1). In the remaining 60 CTA examinations, invasive coronary angiography identified 35 patients with obstructive CAD. All patients (100%) were correctly identified by CTA. However, in one patient, CTA incorrectly identified a significant lesion in the RCA, while an actual obstructive lesion in the LAD was underestimated. In another patient, CTA underestimated a stenosis in the LAD while obstructive CAD in the RCA was correctly identified. In a third patient, CTA underestimated a stenosis in the LCx while obstructive CAD in the LAD was correctly identified. In all other patients, the correct stenosis was identified by CTA. In addition, in a total of 22 patients, CTA correctly ruled out the presence of significant CAD. Only 3 patients were incorrectly diagnosed

with obstructive CAD on CTA. In two patients, a heavily calcified lesion was incorrectly classified as obstructive (LAD, n=1; RCA, n=1). In a third patient, a 40% stenosis of the second diagonal branch was incorrectly deemed obstructive on CTA. Importantly, however, on a patient basis, no patients with significant CAD were missed by CTA. Therefore, the sensitivity and specificity for the detection of ≥ 50% stenosis on a patient basis was 100% and 88% respectively. In addition, positive and negative predictive values were 92% and 100%, respectively. Table 2 presents an overview of diagnostic accuracy and negative and positive predictive values excluding and including non-diagnostic CTA examinations. In addition, Table 3 presents an overview of the diagnostic accuracy for the detection of ≥ 70% coronary stenosis.

DISCUSSION

The present study demonstrated excellent diagnostic accuracy for the assessment of obstructive CAD using 320-row CTA. On a patient level, a negative predictive value of 100% and a diagnostic accuracy of 95% were shown for the detection of ≥ 50% stenosis. When including scans of non-diagnostic image quality, the patient based diagnostic accuracy was 92% while the negative predictive value remained 100%. Importantly, no patients with significant CAD were missed using 320-row CTA. Furthermore, the excellent negative predictive value on segment, vessel and patient basis suggests that CTA might be particularly valuable in the exclusion of significant CAD. These results are in line with previous published data on the performance of 64-row CTA.[9-12]

In addition, excellent diagnostic performance for the evaluation of stenosis ≥ 70% was observed using 320-row CTA, with a negative predictive value of 98% and a diagnostic accuracy of 95% on a patient basis. These findings are in line with previously published data using a 70% stenosis cut-off in the evaluation of CAD using 64-row CTA.[12]

At present, limited data are available on the diagnostic accuracy of 320-row CTA. Previously, a case report has been published directly comparing 320-row CTA and invasive coronary angiography, reporting excellent agreement between the two investigations in a single patient.[13] Furthermore, in a study by Rybicki et al, consistently excellent image quality was observed in over 89% of segments in 40 consecutive patients referred for 320-row CTA.[3] In four of these patients, the observations on CTA were confirmed on invasive coronary angiography.

Technological advancements

Although diagnostic accuracy of 320-row CTA may be comparable to the performance of 64-row scanners, advantages of this new technology lie in improved image acquisition as well as reduced radiation dose compared to retrospectively gated 64-row CTA. For the first time since the introduction of CTA technology, 16-cm volumetric data acquisition within a single gantry rotation has become possible, allowing full cardiac imaging within a single gantry rotation, even in patients with an enlarged heart. Accordingly, single heart beat

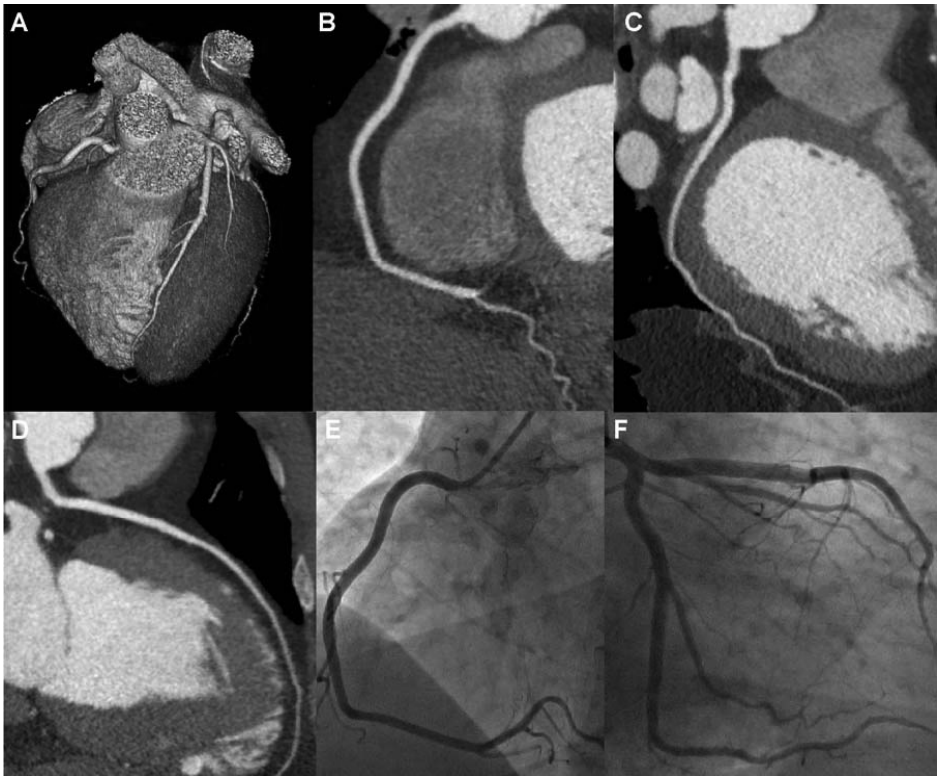

Figure 1 Non-invasive coronary angiography using 320-row CTA revealing the absence of significant CAD.
Panel A shows a 3-dimensional volume rendered reconstruction of the heart, providing an overview of the left anterior descending artery (LAD), proximal left circumflex artery (LCx) and proximal right coronary artery (RCA). Panel B, C and D represent the curved multiplanar reconstructions of a normal RCA, LAD and LCx, respectively, without significant CAD. Panel E and F show the corresponding vessels on invasive coronary angiography.

image acquisition allows for a significant reduction of contrast material and breath-hold time (with a total breath-hold time of 5 s) as compared to CTA systems requiring multiple heart beats to image the entire heart. Figures 1 and 2 represent examples of single heart beat CTA of patients with normal coronary arteries and 3-vessel disease, respectively.

Furthermore, 320-row systems have increased temporal resolution (350 ms per gantry rotation) which reduces cardiac motion artifacts. Although certain types of 64-row systems have a slightly higher temporal resolution (330 ms per gantry rotation), these systems can only cover a small volume (3.2 cm) in a single heart beat.[14] Similarly, dual-source systems, with even superior temporal resolution (83 ms), allow limited cranio-caudal coverage per rotation.[15] In contrast, 320-row CTA allows volumetric data acquisition with full cardiac coverage in a single rotation, eliminating the problem of stair-step artifacts associated with helical and step-and-shoot scanning techniques.

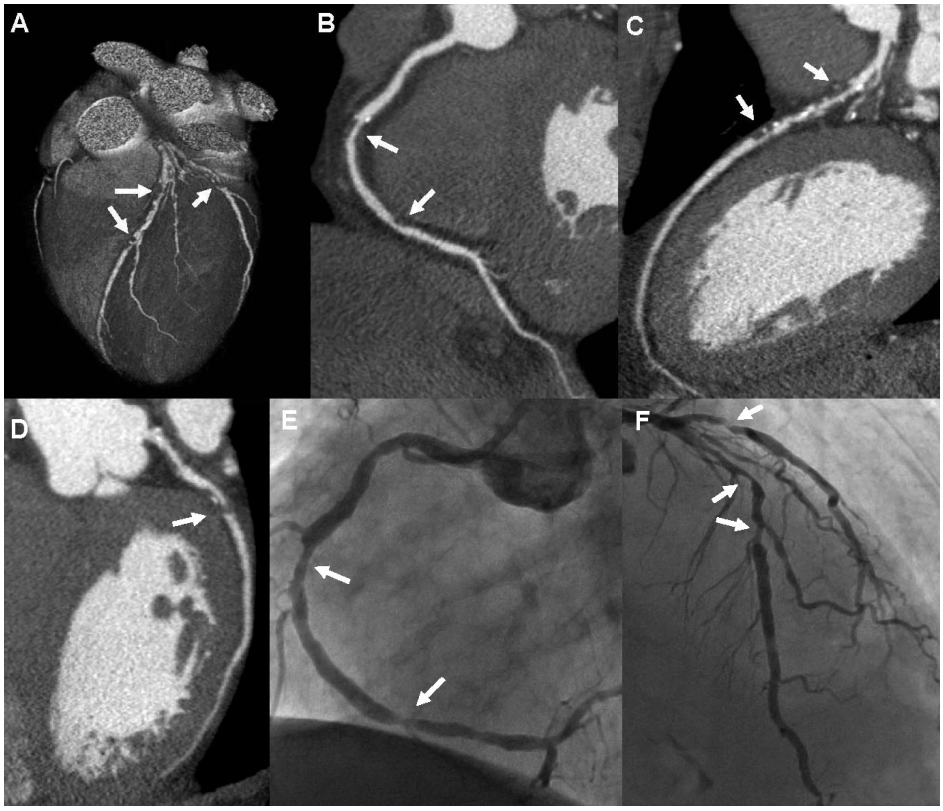

Figure 2 Non-invasive coronary angiography with 320-row CTA revealing 3-vessel disease. Panel A represents a 3-dimensional volume rendered reconstruction of the heart, with an overview of the left anterior descending artery (LAD) and left circumflex artery (LCx), revealing multi-vessel disease (arrows). Panel B shows the curved multiplanar reconstruction of the right coronary artery (RCA) with two significant atherosclerotic lesions (arrows). Panel C reveals multiple severe lesions (arrows) in the proximal segment of the LAD. In panel D, a severe lesion (arrow) in the LCx is shown. Panel E and F are invasive coronary angiograms confirming all findings (arrows).

Recently, several new approaches have been developed to reduce CTA radiation dose. First, dose modulation was introduced, allowing tube current modulation throughout the cardiac cycle[16], decreasing radiation exposure at the cost of increased image noise during low tube current. Subsequently, prospective ECG triggering became available, allowing data acquisition during a narrow pre-defined portion of the R-R interval (usually end-diastolic phase when the heart is relatively motion-free), resulting in a substantial reduction in radiation dose.[17] Importantly, volumetric data acquisition used by 320-row CTA may further reduce radiation exposure by eliminating helical oversampling.[18] Indeed, in the current study, using 320-row CTA in combination with prospective ECG triggering, radiation doses as low as 2.7 mSv were achieved in patients with a low and stable heart rate, while diagnostic image quality was maintained in 94% of patients scanned. Moreover, a recent investigation by Steigner and colleagues, using 320-row CTA in combination with

prospective ECG triggering in the evaluation of 41 patients, concluded that a phase window width of 10% may reduce radiation dose (to an estimated 5.3 mSv) while maintaining diagnostic image quality in over 90% of patients.[19] Therefore, compared to retrospectively gated 64-row CTA, prospectively gated 320-row CTA may considerably reduce radiation exposure to the patient, while maintaining good image quality. Of note, even lower mean radiation doses have been reported recently in studies using new-generation 64-row CTA with prospectively ECG triggered step-and-shoot technology. These studies, however, were performed using maximal dose reduction by using tube voltages with a maximum of 100 or 120 kV as well as performing image acquisition during a minimal phase window of only 75% of the cardiac cycle.[20 21] Other technical advances, such as adaptive collimation and high-pitch spiral acquisition may also allow significant radiation reduction using scanning techniques requiring multiple heart beats.[22 23]

Limitations

Despite promising initial results, the following limitations to the present study should be considered. First, CTA is inherently associated with radiation exposure. Concerns have been raised about radiation dose, especially with respect to the long term sequelae in younger people and women of childbearing age.[24] Accordingly, careful patient selection is warranted and conservative imaging protocols, with respect to radiation dose, should be aimed for. Second, the present study was conduced in a relatively small group of patients. In addition, CTA was performed in patients referred for invasive coronary angiography, creating a selection bias of patients with a relatively high prevalence of significant CAD. Thus, the present diagnostic performance was achieved in an intermediate-to-high prevalence patient population. As a result, the current data may not be directly applicable to patients with a low-to-intermediate prevalence of CAD. Third, at present, quantitative methods to analyze CTA are limited. Nevertheless, development of dedicated quantification techniques is ongoing, and may substantially improve objectivity and reproducibility of the degree of stenosis observed on CTA. Fourth, as a single-centre study, the generalizability of the present results is limited. Last, as CTA and invasive coronary angiography analysis were performed blinded, differences in segment allocation may have occurred. Although differences in segment classification may have affected the results on a segment basis, the effect on vessel and particularly patient basis may have been negligible.

Future directions

Prospective studies in larger patient populations are required to further establish the diagnostic accuracy 320-row CTA in the detection of CAD in a low-to-intermediate likelihood population. Moreover, 320-row CTA acquisition protocols for optimal image acquisition and decreased radiation dose need to be further defined. As CTA technology continues to develop, future research will most likely continue to focus on further decreasing radiation exposure, while maintaining high image quality.

Conclusion

The current study demonstrates that 320-row CTA is highly sensitive for the detection of significant CAD. Importantly, on a patient basis, no patients with significant CAD ≥ 50% were missed. The high negative predictive value suggests this technique is particularly reliable for the exclusion of significant CAD.

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