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FULL PAPER

Quantification of radiation dose reduction by reducing z-axis coverage in 320-detector coronary CT angiography

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Objective: To quantify the radiation dose reduction achievable by minimizing z-axis coverage in 320-detector coronary CT angiography (CCTA).

Methods: We retrospectively reviewed 130 CCTAs performed on 320-detector CT that offers up to 16 cm z-axis coverage (adjustable in 2-cm increments), allowing complete coverage of the heart in a single gantry rotation. For each CT, we obtained the radiation dose [CT dose index and dose-length product (DLP)], measured the z-axis field of view and measured the craniocaudal cardiac size (distance from the left main coronary artery to the cardiac apex). We calculated the radiation dose savings achievable by reducing the z-axis coverage to the minimum necessary to cover the heart using 320 × 0.5-mm (maximum 16 cm) and 256 × 0.5-mm (maximum 12.8 cm) detector collimations.

Results: Results are expressed as mean ± standard deviation. The mean craniocaudal cardiac size was 10.5 ± 1.0 cm, with 85% ($n = 112$) of CCTAs performed with 16 cm of z-axis coverage. The mean DLP was 417.6 ± 182.4 mGy cm, with the mean DLP saving achievable using the minimum z-axis coverage required to completely image the heart being 96.2 ± 47.4 mGy cm, an average dose reduction of 26.9 ± 7.0%. z-axis coverage of ≤12 cm was adequate for 92% and 12.8 cm for 98% of subjects.

Conclusion: Using the minimal z-axis coverage to adequately image the heart is a simple step that can reduce the DLP in 320-detector CCTA by approximately 27%. z-axis coverage of ≤12 cm is adequate for 92%, 12.8 cm for 98% and 14 cm for 100% of patients undergoing CCTA.

Advances in knowledge: Reducing z-axis coverage in 320-detector CCTA can reduce DLP by approximately 27%.

INTRODUCTION

Coronary CT angiography (CCTA) is a highly sensitive, cost-effective, non-invasive imaging test for the diagnosis of coronary artery disease.^{1–3} The increased use of ionizing radiation in medical imaging has led to concerns regarding a potential link between future malignancy and ionizing radiation exposure.^{4,5} Despite these concerns, the individual risk to the patient from a single CT scan is hard to quantify.⁶ Given this uncertainty, it is prudent to optimize scan acquisition parameters to optimize radiation dose in accordance with the as low as reasonably achievable (ALARA) principle.⁷

Since its widespread clinical uptake after the advent of the era of multidetector CT scanners, CCTA has been labelled as an imaging test with a high associated radiation dose; this is mainly due to the high radiation doses associated with CCTA performed on the earlier generations of multidetector CT scanners.⁸ Reducing radiation dose in CCTA examinations is an important patient safety measure.

Advances in scanner technology have reduced radiation dose from CCTA; these include the use of topogram-based tube current modulation, electrocardiogram (ECG)-based tube current modulation, lowering tube peak kilovoltage (kVp), prospecting ECG gating and the use of noise reduction image-processing algorithms, namely iterative reconstruction.^{9,10} Some of these dose reduction techniques, such as reducing kVp or tube current milliamperage (mA), can come at the cost of image quality. Reducing kVp, e.g. from 120 to 100/80 is associated with an increase in image noise that can reduce image quality; a slight increase in mA helps offset some of this increase in image noise whilst still maintaining a total radiation dose less than that of the higher kVp scan. The use of iterative reconstruction algorithms to reconstruct the raw data is also helpful in reducing image noise when scanning a lower kVp.^{11,12}

In CT, an estimation of the total energy given to a patient is reported on the console as the dose-length product (DLP)

measured in mGy cm. The scanner-reported DLP for each CT is based on previous dosimetry measurements obtained with a standard 32-cm body phantom, the CT dose index (CTDI_{vol}). The reported DLP is a product of the CTDI_{vol} and the z-axis irradiated length. CTDI_{vol} and DLP are the established dose quantities for CT radiation dose assessment.¹³

In general, there is a linear relationship between the length of the patient scanned, the z-axis field of view (FOV) and total radiation delivered as measured by DLP.¹⁴ Automatic dose modulation, which alters the radiation dose delivered to the patient according to the attenuation of the tissue being imaged, can affect the strict linearity of this relationship, but in general, the radiation dose increases with z-axis coverage in a linear fashion. This is the basis behind one of the simplest radiation dose reduction techniques that can be employed, reducing z-axis coverage.^{15–17} Multidetector CT allows for wider coverage of the patient in the z-axis direction during each gantry rotation, reducing overall scan time. The larger the number of detectors in the z-direction, the fewer the gantry rotations required to completely image the heart. State-of-the-art CT scanners including the Siemens Definition Force (Siemens, Germany); Toshiba Aquilion™ One and Toshiba Aquilion One Vision (Toshiba, Japan); and GE Revolution (General Electric), allow complete cardiac coverage in CCTA acquisition in a single heartbeat, reducing the risk of deleterious misregistration artefacts (stair-step) that can occur with helical acquisitions over a number of heartbeats. State-of-the-art dual source scanners, such as the Siemens Definition Force, provide this single heartbeat complete cardiac coverage mainly due to their scan speed rather than collimation width. Two of these vendors currently offer wide-area detector scanners with 16 cm of coverage in the z-axis, providing complete anatomical volume coverage of the heart in a single gantry rotation acquisition (320-detector = Toshiba Aquilion One, Toshiba Aquilion One Vision; 256-detector = GE Revolution).¹⁸ The aim of this study is to quantify the reduction in radiation dose achievable by using the minimal achievable z-axis coverage in 320-detector CCTA.

METHODS AND MATERIALS

Patients

The institutional review board of the Brigham and Women's Hospital approved this study. We retrospectively reviewed a random sample of 130 CCTAs performed in our institution between 2010 and 2016. We included CTs performed on two 320-detector CT scanners (Aquilion One and Aquilion One Vision; Toshiba, Japan) for evaluation of the coronary arteries. CCTAs performed on scanners other than the aforementioned models and scans performed for indications other than coronary artery assessment were excluded. We excluded patients with high heart rates (HRs) [>75 beats per minute (bpm)], as they had their CT scans performed on a separate dual-source CT.

Coronary CT angiography technique

All CCTAs were performed on 320-detector CT scanners (Aquilion One or Aquilion One Vision). Oral beta-blocker metoprolol pre-medication (50–200 mg Lopressor®; Novartis, Basel, Switzerland) was administered to patients approximately 1 hour prior to imaging. Patients received 0.8 mg of sublingual nitroglycerin (Nitrostat®; Pfizer) for coronary vasodilatation

prior to scanning, if no contraindications. CCTAs were acquired with a slice collimation and increment of 0.5 mm and a gantry rotation time of 350 ms for the Aquilion One and 275 ms for the Aquilion One Vision. Patients were scanned at either 120 or 100 kVp with automated tube current mA modulation. Prospective ECG gating was used as follows: for patients with HRs <65 bpm, we used a phase window of 70–80% of the R–R interval, and in those with a HR between 65 and 75 bpm, we used a phase window of 30–80% of the R–R interval.¹⁰ Patients with a HR >75 bpm were scanned on a separate dual-source CT and were not included in the study. A bolus-tracking technique with the region of interest in the middle of the volume in the descending thoracic aorta was used to time CCTA acquisition. Iodinated intravenous contrast material (50–60 ml of Isovue-370; Bracco Diagnostics; Princeton, NJ) was injected at a rate of 5/6 ml per second (for 100- and 120-kVp scans, respectively), followed by a 40 ml of saline chaser at the same injection rate as the iodinated intravenous contrast material.

As previously described, 320-detector CT offers up to 16 cm of z-axis coverage in a single gantry rotation, allowing complete cardiac coverage in a volume acquisition, free from misregistration artefact. z-axis coverage length is adjustable prior to scan acquisition in the commercially available 256- and 320-detector scanners. For the 320-detector scanners used in this study, the z-axis coverage is adjustable in 2-cm increments up to a maximum of 16 cm when operated in the 320×0.5 -mm detector collimation, with an additional detector collimation setting using 256×0.5 -mm detectors, providing z-axis coverage of 12.8 cm. When performing a volume acquisition with the Aquilion One Vision CT scanner, CT acquires preview, low-dose and axial non-contrast CT images of the top and bottom of the prescribed volume. The preview slices can be used to determine whether the anatomical coverage is adequate, prior to proceeding with the diagnostic study. When reviewing these preview slices, it is of particular importance to ensure that the left main or left anterior descending (LAD) coronary arteries are not present on the top preview slice, as they are then in danger of being excluded from the diagnostic CCTA. If mediastinal fat is present on the bottom preview slice, then there is a risk of excluding the cardiac apex if there is further inferior movement of the heart during the diagnostic scan. If there is concern about the scan coverage at this stage, the position and size of the CT volume can be altered before proceeding with the diagnostic scan. A separate preview slice is acquired in the middle of the prescribed volume for placement of the bolus-tracking region of interest, used to trigger the diagnostic CCTA acquisition. The same breathing instructions (end inspiration—“take a breath in and hold it”) are used for topogram, preview slices and the diagnostic CT acquisition. All patients underwent breath-hold rehearsal prior to scanning with a radiologist, as per routine division protocol.

Data collection and analysis

Using the electronic patient record, we obtained basic demographics for each patient (age, height and weight) and calculated each patient's body mass index (BMI) and body surface area (BSA). From the console dose report sent with the images for each CCTA, we obtained the following technical and

radiation dose data: (1) kVp of the cardiac volume acquisition, (2) CTDI_{vol} of the cardiac volume acquisition, (3) DLP of the cardiac volume acquisition and (4) total scan DLP. The total scan DLP incorporates the sum of the radiation doses for CCTA volume acquisition, the topograms (frontal and lateral), the monitoring scan used for scan timing and the preview slices used to determine adequate anatomical coverage.

Using sagittal reformats of the CCTA images, the z-axis coverage and the individual cardiac z-axis size for each CT was measured (DJM, AK and NH); cardiac z-axis size was defined as the craniocaudal distance from the superior extent of the left main coronary artery to the cardiac apex.

Using the measured heart size for each patient, we calculated the minimal z-axis coverage required for each patient (in 2-cm increments), the individual DLP saving possible by using this minimal z-axis coverage compared with the actual z-axis coverage used, and the radiation dose saving per 2-cm increment reduction in the z-axis length. We also evaluated whether the additional 256×0.5 -mm detector collimation with z-axis coverage of 12.8 cm would be sufficient to completely image the heart, and the potential DLP saving using this compared with the actual z-axis coverage.

Statistical analysis

Continuous variables are presented as mean $\pm$ standard deviation. The categorical variables are presented as frequencies and percentages. Group comparisons were performed using χ^2 test for categorical variables and Spearman's rank test for continuous variables. All statistical analyses were performed using the statistical software GraphPad® (GraphPad Software Inc., La Jolla, CA). A value of $p < 0.05$ was considered significant.

RESULTS

We reviewed the CCTAs of 130 patients (74 males and 56 females). The average age of our cohort was 60 ± 11.8 years, with an average BMI of $28.3 \pm 4.4 \text{ kg m}^{-2}$ and an average BSA of $1.95 \pm 0.65 \text{ m}^2$. The majority of the CCTAs reviewed were performed with z-axis coverage of 16 cm (87.7%, $n = 114$), with

11.5% ($n = 15$) performed with 14 cm coverage and 0.8% ($n = 1$) with 12 cm.

The z-axis heart length could not be measured in 11 patients (8%) due to inadequate anatomical coverage of the cardiac apex on the CT. These patients were excluded from the dose reduction analysis. The average heart size in the craniocaudal direction (measured from the left main coronary artery to the cardiac apex) was 10.5 ± 1.0 cm (range 8.1–13.3 cm). There was a significant correlation between patient height and craniocaudal heart length (Figure 1, $p < 0.0001$).

The majority of CCTAs were acquired at 120 kVp (78%, $n = 101$), with 22% of scans acquired at 100 kVp ($n = 29$). The average total and volume radiation doses are presented in Table 1. The cardiac volume CT acquisition accounted for, on average, $86.7 \pm 7.8\%$ of the total DLP.

Using the measured cardiac z-axis size, we calculated the minimal z-axis FOV required for each patient in 2-cm increments for the 320×0.5 -mm detector collimation (Table 2) and, for the additional 256×0.5 -mm detector collimation, which provides 12.8 cm of z-axis coverage. z-axis coverage of 12 cm provided satisfactory coverage for 92% of patients. Applying the minimal z-axis FOV for each patient, the mean DLP is $267.4 \pm 130.5 \text{ mGy cm}$, a mean reduction in DLP of $96.2 \pm 47.4 \text{ mGy cm}$, an average reduction of $26.9 \pm 7.0\%$ of the volume acquisition and $23.5 \pm 6.7\%$ of the total DLP. The overall mean DLP saving per 2-cm increment reduction in z-axis coverage is $46.3 \pm 21.8 \text{ mGy cm}$ ($12.8 \pm 0.7\%$). The 256×0.5 -mm detector collimation with 12.8 cm z-axis provides sufficient anatomical coverage for 98% ($n = 117$) of the evaluable subjects. Applying this z-axis coverage, the mean DLP is $296.1 \pm 137.0 \text{ mGy cm}$, a mean DLP reduction of $68.7 \pm 37.0 \text{ mGy cm}$ ($18.5 \pm 3.8\%$) from the volume acquisition.

Linear regression analysis demonstrates a significant correlation between potential DLP saving and BMI, BSA and z-axis heart size (Figure 2a–c). The relatively low R^2 values demonstrated in these linear regression plots are likely due to high variability of data around the regression lines, which can in part be explained by the multiple differing factors that contribute to radiation dose, but there is evidence of a statistically significant trend towards an association between DLP saving and z-axis cardiac size, BMI and BSA.

Figure 1. Patient height (m) vs z-axis heart size (cm).

Table 1. Coronary CT angiography radiation dose

Demographic	Mean $\pm$ SD
CTDI_{vol} (mGy)	23.0 ± 10.4
Total DLP (mGy cm)	417.6 ± 182.4
Cardiac volume DLP (mGy cm)	362.8 ± 166.6
Minimal z-axis FOV DLP (mGy cm) ^a	267.4 ± 130.5
DLP saving per 2-cm FOV reduction (mSv) ^a	46.3 ± 21.8

CTDI_{vol} , CT dose index volume; DLP, dose-length product; FOV, field of view; SD, standard deviation.

^aUsing the 320×0.5 -mm detector collimation.

Table 2. Minimal required z-axis field of view (FOV)^a

z-axis FOV (cm)	% (n = 119)
16	0 (0)
14	8 (9)
12	61 (73)
10	31 (37)

^aUsing 320 × 0.5-mm detector collimation.

DISCUSSION

The overall radiation doses reported in our cohort (Table 1) undergoing 320-detector CCTA are within reported dose reference levels for CCTA.^{19,20} Continued efforts need to be made to further reduce CCTA radiation dose in keeping with the ALARA principle.⁷ The results from our study suggest that the use of minimum z-axis coverage can yield a significant reduction in radiation dose; we found a mean radiation dose saving of approximately 27% from a reduction in z-axis coverage from 16 cm to the minimal length required to cover the heart. Our results suggest that when performing CCTAs with a 320-detector CT, a z-axis coverage of 12 cm is adequate for >90% of patients, with 12.8-cm z-axis coverage (available with the 256 × 0.5-mm detector collimation) adequate for 98% of subjects. The mean cardiac z-axis size of 10.5 ± 1.0 cm in our cohort is similar to that reported in a previous series which measured cardiac size using ECG-gated calcium score CTs.²¹ No patient in our cohort required 16 cm of z-axis coverage, with only a small number (8%) requiring 14 cm (Table 2). Based on our findings, a reduction in z-axis coverage from 16 to 14 cm, which was adequate for our entire cohort, yields on average an approximately 13% reduction in radiation dose (DLP 46.3 mGy cm).

z-axis coverage is an easily adjustable parameter that can directly reduce radiation dose due to the linear relationship between z-axis coverage radiation dose.^{14–16} When using wide-area detector large cone beam CT scanners, reducing z-axis coverage may have an additional benefit on image quality due to less scattered radiation by reducing the cone beam angle. One of the challenges with the use of reduced z-axis coverage in a volume CT acquisition with a wide-area detector CT scanner is the potential to exclude an important part of the coronary artery

anatomy if the scan coverage is prescribed incorrectly. In a volume acquisition, the entire data set is acquired in a single gantry rotation, thus it is not possible to alter the scan FOV during acquisition. If the cranial slice of the volume is prescribed too low, the left main/LAD coronary artery is at risk of being excluded from the scan volume. If the lowermost slice of the prescribed volume is too high, there is the risk of excluding the cardiac apex, although this usually poses less of a diagnostic problem due to the relatively smaller size of the coronary arteries at the apex. Of note, the 8% of scans in our cohort with inadequate anatomical coverage were performed before the top and bottom preview slices were available for review prior to the diagnostic CT.

Based on our data, we now employ a hybrid technique when prescribing z-axis length for our CCTAs. As previously described, the 320-detector CT scanners that we routinely use for CCTAs acquire “preview” axial slices at the top and bottom of the prescribed volume before commencement of the diagnostic scan. These are very-low-dose CT images, with an approximate DLP of 1.0 mGy cm per slice, and are acquired with the same breathing instructions (end inspiration) that are used for the acquisition of the topogram and diagnostic CCTA. We routinely rehearse these breathing instructions with the patient before getting on the scanner to improve compliance and reproducibility of the breath-hold; this also allows for the identification of any unusual effects that breath holding may have on the HR.²² Acquisition of these top and bottom preview slices allows the operator to determine whether the prescribed z-axis provides adequate anatomical coverage. Based on these results, we now begin by prescribing a 12-cm volume on the topogram rather than on the standard 16-cm volume. We prefer to use the 240 × 0.5-mm detector collimation, as this allows the operator to easily increase the z-axis coverage to 14 cm if required. We use the middle of the left main pulmonary artery on the frontal topogram to mark the superior extent of the volume and the position of the apex on the lateral topogram as the inferior marker. The preview slices can be used to confirm that the prescribed coverage is not excluding any portion of the heart, paying particular reference to not cutting off the left main or LAD in the top slice. If there is concern about the scan coverage at this stage, the position and size of the CT volume can be altered before proceeding with the diagnostic scan (Figure 3). When scanning patients with higher HRs (65–75 bpm) with

Figure 2. (a) Dose-length produce (DLP) saving (mGy cm) vs body mass index (BMI) (kg m^{-2}). (b) DLP saving (mGy cm) vs body surface area (BSA) (m^2). (c) DLP saving (mGy cm) vs craniocaudal heart size (cm).

a phase window of 30–80%, it is prudent to take into account potential changes in z-axis position of the heart between the systole and diastole, with increased coronary artery velocity during the systole compared with during the diastole, most marked in the right coronary artery.²³ Kataria et al²⁴ measured coronary artery displacement in the *x*-, *y*- and *z*-axis with ECG-gated CT in an effort to reliably exclude the coronary arteries from the chest radiotherapy field for patients with breast or thoracic malignancy. They found a mean displacement in *z*-axis position between systole and diastole of 3.6 mm for the LAD, 5.1 mm for the left circumflex artery and 5.9 mm for the right coronary artery. Increasing the *z*-axis coverage by approximately 1 cm, or by the nearest allowable increment, is therefore a prudent step when scanning patients with higher HRs at 30–80% of the cardiac cycle to avoid excluding coronary artery anatomy due to *z*-axis motion of the heart between the systole and diastole. In practice, we have found this preview slice technique to be a straightforward method in helping to reduce CCTA radiation dose, which can be easily incorporated into routine clinical workflow and can be used along with other dose reduction methods such as scanning at lower kVp. Our results indicate that a reduction in *z*-axis coverage from 16 to 14 cm can help reduce the DLP by approximately 13% whilst providing sufficient anatomical coverage. We have not found in our experience thus far any patient requiring 16 cm of *z*-axis coverage.

Other methods have been employed to accurately determine the CT FOV without cutting off a portion of important cardiac anatomy. Earls et al⁹ and Zimmerman et al²¹ advocate performing non-contrast ECG-gated calcium score CT prior to CCTA. This method has the advantage of allowing determination of the exact position and heart size prior to CCTA, but performing an additional CT scan does incur increased radiation dose. Using the frontal and lateral topogram alone to determine scan range is another potential method of deciding *z*-axis coverage. This removes the problem of increased radiation dose incurred by the additional calcium score CT but is less accurate. The exact location of the coronary arteries cannot be

accurately identified by the sole use of the topogram, as there is heterogeneity in the relationship between the position of the left main and left anterior descending coronary arteries and chest anatomical landmarks.²⁵

Quantification of radiation dose delivered to an individual patient is an important part of quality and safety control in CCTA. The CTDI_{vol} and DLP values utilized in this study are established dose quantities in CT and are readily available on the CT console after each individual scan.¹³ The CTDI_{vol} is a standard method of comparing radiation output between different CT scanners; it is sensitive to changes in tube voltage and current and gantry rotation time and is used to calculate DLP. The scanner-reported CTDI_{vol} for each CT is based on previous scanner-specific dosimetry measurements obtained with a standard 32-cm body phantom. There are problems with these dose metrics, however, as they do not always take into account patient size. Because of this, interest has grown in using site-specific dose estimation as a more accurate method of estimating radiation dose in CCTA.²⁶ This method involves multiplying the CTDI_{vol} by a conversion factor derived from the patient effective diameter—this is calculated by obtaining the square root of the product of the patient's anteroposterior and lateral diameters (in metres) measured on axial CT images. Site-specific dose estimation appears to be a more accurate measurement of individual patient dose than the phantom-derived CTDI_{vol}, but it cannot yet be simply incorporated into an assessment of DLP;²⁷ this currently precludes its applicability in the assessment of *z*-axis length on radiation dose, but it may be proven to be a more accurate measurement of delivered dose in the future.

Effective dose [*E*, measured in millisieverts (mSv)] is another metric used as a broad comparison of radiation dose between different diagnostic imaging techniques and other sources of ionizing radiation. *E* is calculated by multiplying the mean absorbed dose (DLP for CT scans) by the *k*-coefficient, an organ-specific weighting factor set out by the International Commission on Radiological Protection (ICRP) ($E = k \times \text{DLP}$).^{28,29}

Figure 3. Electrocardiogram-gated CCTA planning in a 62-year-old male with chest pain. (a) Frontal topogram shows the initial prescribed volume (box), with the thumbnail images on the left demonstrating the corresponding preview axial images of the top and bottom of the prescribed volume. The left main coronary artery (curved arrow) is visible on the top preview slice (superior dashed arrow); this prescribed volume will exclude an important part of coronary anatomy if left unchanged. The inferior preview slice (lower dashed arrow) is in a satisfactory position, with no mediastinal fat visible. (b) Frontal topogram with top and bottom preview slices in the same patient following an increase in the prescribed volume (box). The cranial preview slice (superior dashed arrow) is at the level of the main pulmonary artery and is not in danger of excluding the left main coronary artery. CCTA was subsequently performed with satisfactory anatomical coverage.

Owing to the specific organ weighted k -coefficient used in its calculation, the relationship between E and the z -axis coverage is not strictly linear, however, reducing z -axis coverage will reduce E through reducing DLP. E is an attempt at a risk-adjusted metric of radiation dose, with the primary purpose of comparing patient population radiation exposures; it is not designed to compare individual radiation dose exposure, therefore we did not use E as our dose metric.^{13,30} Another difficulty in using E for CCTA dose estimation is that the older IRCP chest k -coefficient is based on a scan coverage area incorporating the entire thorax, rather than the shorter craniocaudal length used in CCTA.³¹

We used the console-displayed dose metrics (CTDI_{vol} and DLP) as an estimation of the radiation dose; this a potential limitation of our study, as these values in wide-area detector large cone beam CT scanners have been found to underestimate the actual amount of energy delivered to the patient when compared with direct dose measurements.^{32,33} The potential limitation of radiation dose assessment using console-displayed dose metric values in wide-area detector large cone beam CT scanners is likely exacerbated as the cone beam angle increases with increasing z -axis coverage; this may also affect the linear relationship between z -axis coverage and radiation dose.^{32,33} Another potential confounder of a strict linear relationship between DLP and z -axis is the use of automatical dose modulation, which alters the radiation dose

delivered according to the attenuation of the tissue within the scanned volume. For these reasons, Monte Carlo estimations of radiation dose are more precise than the console-displayed dose metrics used in this study,³⁴ however, this is a costly and time-consuming technique. The dose metrics that we employed represents the current, real-world clinical standard^{14,35} and are readily applicable to everyday clinical practice when used in wide-area detector large cone beam CT scanners for CCTA. Despite these inherent limitations in radiation dose estimates by using the console-derived estimates, this does not change the central result of our study that reducing z -axis irradiated length in 320-detector CCTA is a simple step that can result in a reduction in radiation dose, along with other dose reduction techniques. Other limitations in our study include its retrospective design, the limited assessment to 320-detector CT scanners using only volume acquisitions and the exclusion of patients with high HRs, who had their scans performed on a dual-source CT scanner.

CONCLUSION

Using the minimal z -axis coverage required to adequately image the heart is a simple step that can lead to a DLP reduction of approximately 27% in 320-detector CCTA. z -axis coverage of ≤ 12 cm is adequate for 92%, 12.8 cm for 98% and 14 cm for 100% of patients when performing CCTA in a wide-area detector large cone beam CT scanner.

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