Research Correspondence

Reduction in radiation exposure with coronary computed tomography over seven years in a real world setting

1. Introduction

Multi-center randomized controlled studies have shown that new scanner technologies and novel dose reduction strategies have led to significant reduction in radiation dose, when evaluated over a short period of time within a carefully monitored trial setting. However, there is a paucity of data looking at the impact of these strategies over a longer period of time in a real world setting. Our objective was to evaluate longitudinal trends in radiation exposure from coronary CT angiography (CCTA) in a busy real world clinical practice over a seven-year period.

2. Materials and methods

Data on all consecutive CCTAs performed at a large academic center (1 university hospital, 1 community hospital) from 2008 to 2014 were collected prospectively. Over this time period, there were improvements in scanner technology – prospective ECG triggered and high pitch helical acquisition protocols, and introduction of novel dose reduction strategies - automatic tube voltage selection and iterative reconstruction. The primary endpoint was the total radiation exposure, estimated as effective radiation dose [in mSv, calculated as dose-length product (DLP) X 0.014]. Univariate and multivariate linear regression to adjust for age, body mass index (BMI), calcium score, heart rate (HR), stent, and coronary artery bypass grafting surgery (CABG) were performed. Waiver of consent from the Institutional Review Board was obtained.

3. Results

A total of 2543 CCTAs were performed over the study period, 901 (35.4%) at the university hospital and 1642 (64.6%) at the community hospital. Patient specific baseline characteristics and scan parameters are listed in Table 1. There was a significant decrease in mSv over the course of the study period, coinciding with introduction of new scanner technology and dose reduction strategies (Fig. 1; p < 0.001). The effective radiation dose decreased from 20.1 mSv in 2008 to 5.2 mSv in 2014 (p < 0.001). Using multivariate linear regression, we found that effective radiation dose decreased by 0.25 mSv per year (p < 0.001) after adjustment for patient-specific factors such as age, BMI, calcium score, stent, heart rate, and CABG.

4. Discussion

New scanner technology and dose reduction strategies have led to significant reduction in effective radiation dose from CCTA in a busy real world setting. The biggest drop in radiation dose occurred with the introduction of new dual source scanners (Siemens 128 slice dual source SOMATOM Definition Flash. Siemens Healthcare, Erlangen, Germany). Given improved temporal resolution, this scanner allowed for implementation of dose reduction scanning protocols such as prospective ECG triggered axial and high pitch helical acquisition protocols. Over time, there was also a move towards using dose modulation with retrospective ECG gating, wherein full radiation is used for only a portion of the cardiac cycle (usually diastole to minimize coronary motion) as opposed to no dose modulation wherein full radiation is used through out the cardiac cycle. Prior to this, scans were performed on a Siemens 64-slice SOMATOM sensation scanner, with retrospective ECG gating and no dose modulation. Readers were free to choose the protocol at their discretion, though institutional guidelines recommended the following: for HR < 60 - high pitch helical acquisition at 70% of the cardiac cycle or prospective ECG triggered axial acquisition at 60–65% of the cardiac cycle, for HR 60–65 - prospective ECG triggered axial acquisition at 60–70% of the cardiac cycle, for HR > 65 - retrospective ECG gating with dose modulation at 40–70% of the cardiac cycle.

This also coincided with a change from test bolus technique to bolus tracking (150 Hounsfield units for 100 kV in proximal ascending aorta). A non-contrast calcium scan was performed in all patients above 40 years and absence of known coronary artery disease.

A smaller drop in radiation dose was noted with implementation of other dose reduction strategies, such as automatic tube voltage selection (allowing for scanning at 100 kV for most non-obese patients vs a standard 120 kV for all patients) and iterative reconstruction. Iterative reconstruction leads to better image quality by minimizing noise and artifacts, and thus allows for lower radiation to be used upfront. The small increase in radiation dose towards the end of the study period was presumably from referral of more complex patients as CCTA gained more acceptance in the referring practice group.

Funding

None.

Disclosures

None.
Table 1
Patient and scanner characteristics.

| Characteristic          | 2008–2014 (n = 2543) |
|-------------------------|----------------------|
| Male                    | 1,056/2,266 (46.6%)  |
| Age (y)                 | 55 ± 13              |
| BMI                     | 30.0 ± 8.7           |
| Heart rate              | 60 ± 8               |
| Calcium Score           | 95.4 ± 207.9         |
| Prior PCI               | 31 (1.2%)            |
| Prior CABG              | 24 (0.9%)            |
| Diabetes                | 256 (10.1%)          |
| Hypertension            | 953 (37.5%)          |
| Family history of CAD   | 839 (33.0%)          |
| Smoker                  | 524 (20.6%)          |
| High cholesterol        | 980 (38.5%)          |
| Oral β-blocker (mg)     | 81 ± 27              |
| IV β-blocker (mg)       | 24 ± 15              |
| Nitroglycerin given     | 2,077 (81.7%)        |
| Exam kVp                | 105.8 ± 12.0         |
| Injection rate (mL/s)   | 6.09 ± 0.3           |

BMI – body mass index, PCI – percutaneous coronary intervention, CABG – coronary artery bypass grafting, CAD – coronary artery disease.

Fig. 1. Radiation Exposure 2008–2014.
1. New dual source 128-slice scanner at community hospital.
2. New dual source 128-slice scanner, automatic tube voltage selection, and iterative reconstruction at university hospital.
3. Automatic tube voltage selection and iterative reconstruction at community hospital.

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References
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