Audit of doses of multidetector computed tomography coronary angiography with correlation to patient physical parameters

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Purpose

Computed Tomography Coronary Angiography (CTCA) has demonstrated useful clinical application in the assessment of patients presenting with typical chest pain and low to intermediate risk for cardiac disease. Its high sensitivity makes it a more effective "rule out" test than traditional investigation methods that don't use ionising radiation (stress echocardiography or echosonography). Accordingly, in order to retain its advantage, it is important to optimise scanning protocols to provide a diagnostic examination while minimising patient dose.

Methods and Materials

Consecutive CT coronary angiographic studies were identified from May 2013 to December 2013. Examinations were limited to those performed in a single imaging department on a Siemens Somatom Definition Flash CT using current departmental scanning technique.

Using a dose audit tool, data was collected in relation to the following parameters:

- Technique used ("Flash" or "Step and Shoot");
- The scanning parameters (mAs, kV, scan extent);
- Operator variation to routine parameters;
- Dose (total DLP and CTDI volume); and
- Patient variables (body mass index (BMI), girth, effective diameter, heart rate).

Routine scanning protocols were based on patient BMI, separating each acquisition type into BMI <25, 25-30 and >30.

A quality assessment of the studies was performed by two reporting Radiologists experienced in CTCA using a four point scale (1 = nondiagnostic, 2 = adequate, 3 = good and 4 = excellent image quality). Scores of 1, 2 and 3 required justification of the score (step artefact, stent blooming, calcium blooming, noise mottle, movement blur or low contrast). Each target vessel (left main, left anterior descending, circumflex and right common coronary arteries) were analysed separately.

Results
Summary of Data:

A total of 73 cases were identified, 2 were excluded as CTCA was not performed following calcium scoring. There were 29 patients in the "Flash" acquisition group and 42 patients in the "Step and Shoot" acquisition group.

12 cases were excluded from BMI analysis as this data was not available on review of the request form, however these cases were included in all analyses not requiring BMI data.

One case was excluded from Effective Patient Diameter analyses as an accurate AP diameter was unable to be measured from the images available on PACS.

A summary of dose (Total DLP) is presented in Table 1 and CTDIvol in Table 2. Box plot analysis of Total DLP and CTDIvol by scanning protocol is presented in Figure 1 and 2, respectively. Analysis of the BMI <25 was excluded due to small group size. Statistical outliers are identified, but included within the analysis due to the small patient cohort.

Statistical analysis:

The mean total DLP is significantly different between the two protocol groups (Mean total DLP Flash: 229.6; Step and Shoot: 548.5 t=-6.3, P<0.0001). The mean CTDIvol is also significantly different between the two protocol groups (Mean CTDIvol Flash: 6.8; Step and Shoot: 32.6 t=-8.2, P<0.0001).

Given the difference in mean dosage based on protocol, further investigation within each protocol group was undertaken to determine if there was statistical evidence of variation in dosage by BMI group. This analysis was limited by the small numbers for BMI <25. Accordingly, for the regression analysis to compare the mean difference between two groups, BMI 25-30 was used as the reference level and mean differences are relative to this group.

There was no significant difference between the mean total DLP for BMI >30 or BMI <25 with BMI 25-30 for the flash group (Mean total DLP >30: 231.3; BMI <25: 149.3, P=0.15; BMI >30: 310.9, P=0.11). There is a significance between the mean CTDIvol for BMI >30 and BMI <25 with BMI 25-30 for the flash group (Mean CTDIvol >30: 6.3; BMI <25: 3.72, P<0.001; BMI >30: 10.05, P<0.001).

For the step shoot group, there was no significant difference between BMI groups for Total DLP or CTDIvol.
BMI Analysis:

Differences in doses was due primarily to protocol. Only in the flash cohort was there a significant difference in mean CTDIvol dosage by BMI. This is not readily apparent in the Step and Shoot cohort partly due to more extreme outliers with this method.

- There was a strong positive correlation between BMI and effective diameter ($\# = 0.69$)
- There was a moderate positive correlation between BMI and total DLP ($\# = 0.37$)
- There was a moderate positive correlation between BMI and CTDIvol ($\# = 0.36$)

Effective Diameter analysis:

For the Flash acquisition cohort, patient CTDIvol is strongly positively correlated with effective diameter. Fitted line suggests that CTDIvol increases with increasing effective diameter (Figure 3).

There is an even closer correlation between CTDIvol and effective diameter when the patients were divided into BMI protocol groups (Figure 4).

Heart rate analysis:

Heart rate characteristics are summarised in Table 3.

The mean average patient heart rate for the Flash group was significantly lower compared to the Step and Shoot group (Mean average HR Flash: 59.4, SS: 63.5, $t=-2.4$ $P =0.009$). There was no significant difference in mean patient heart rate variability between the Flash and Step and Shoot cohorts (Mean Heart Rate variability Flash: 19.0, SS: 19.7, $t=-0.1$, $P =0.88$).

There was almost no correlation between Total DLP and average heart rate for Step and Shoot subjects ($\# = 0.0289$) and a negligible negative correlation between Total DLP and average heart rate for Flash subjects ($\# = -0.19$).

There was negligible positive correlation between CTDIvol and average heart rate for Step and Shoot subjects ($\# = 0.15$) and almost no correlation between CTDIvol and average heart rate for Flash subjects ($\# = 0.0006$).

Subgroup analysis:
A reproducible subgroup was selected for analysis to correct for average heart rate differences. Seventeen Flash patients with an average heart rate of 55 to 65 demonstrated a strong positive correlation between CTDIvol and effective diameter ($# = 0.63$) (Figure 5). The mean CTDIvol for this group was 6.28.

Twenty-five Step and Shoot patients with an average heart rate between 55 and 65 demonstrated a moderate positive correlation between CTDIvol and effective diameter ($# = 0.30$) (Figure 6). The mean CTDIvol for this group was 31.26.

**Quality analysis:**

The mean quality score of all assessed vessels was 2.9 between two readers.

**Images for this section:**

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<th>Table 1: Total DLP by protocol assigned BMI and acquisition type</th>
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<th>Table 2: CTDIvol by protocol assigned BMI and acquisition type</th>
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<th>Table 3: Heart rate characteristics by acquisition type</th>
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Fig. 1: Boxplots of Total DLP by assigned BMI protocol groups
Fig. 2: Boxplots of CTDIvol by assigned BMI protocol groups
Fig. 3: CTDIvol against effective diameter (mm) for Flash protocols
**Fig. 4:** CTDIvol against Effective Diameter (mm) for Flash acquisitions, by BMI protocol groups
**Fig. 5:** CTDIvol against Effective Diameter (mm) for Flash acquisitions with average heart rate of 55-65
Fig. 6: CTDIvol against Effective Diameter (mm) for Step and Shoot acquisitions with average heart rate of 55-65
Conclusion

This study has identified a positive relationship between dose and BMI. However a closer relationship exists between dose and effective patient diameter. Given close positive correlation between effective patient diameter and BMI, BMI acts as an adequate measurement to guide imaging protocol selection in clinical practice.

Almost all studies were of adequate diagnostic quality or better. This audit serves as a baseline assessment of imaging quality if protocol changes were implemented.

This dose audit tool is a simple way to analyse the performance of the Siemens Somatom Definition Flash CT. This tool could be adapted to reassess CTCA doses within the same department or compare dose performance with other departments in order to optimise dose and diagnostic quality.

Personal Information

References
