Correlation of Patient Vertical Centering with Radiation Output in Adult Abdominopelvic CT

Phillip M. Cheng, MD, MS, University of Southern California (Presenter)

Hypothesis

Automated retrospective evaluation of patient centering in CT is useful for calculating the dependence of scanner radiation output on patient vertical positioning, and for imaging quality control.

Introduction

Automatic tube current modulation techniques are used in CT to provide predictable image noise in response to variation in patient size. It has been reported that inappropriate centering of the patient in the CT gantry influences the operation of the current modulation, due to greater magnification of body size when the patient is positioned closer to the tube during the acquisition of a frontal localizer radiograph.

However, the effect of patient off-centering on scanner output is expected to vary among scanners. In addition, systematic evaluation of patient centering in clinical scans and correlation with radiation output has been limited in previous reports. Centering data in prior studies has typically been reported on phantoms of fixed size, from localizer images of clinical scans, or from table heights of clinical scans. Furthermore, the magnitude of the effect of inaccurate patient positioning on scanner radiation output in clinical scans is unclear.

The aims of this study were to demonstrate a method for estimating the center of mass from volumetric data in clinical CT scans, to retrospectively calculate both the effective diameter and the vertical centering of patients undergoing abdominopelvic CT studies, and to correlate the centering with the average CTDIvol produced by the scanner’s automated tube current modulation system.

Methods

656 consecutive contrast-enhanced abdominopelvic scans using the same protocol and automatic tube current modulation settings on a Philips Brilliance 64 MDCT scanner were retrospectively evaluated. The scans were performed using constant scanner parameters with a kV of 120 kV, current modulation (Z-DOM) along the z-axis of the patient with an average mAs/slice of 105 mAs, pitch of 0.671, rotation time of 0.5 s, and collimation of 64 x 0.625 mm. The current modulation on the scanner is based on a posteroanterior localizer scan. Studies were reconstructed at 2 mm slice thickness with iterative reconstruction. The table height, reconstruction diameter, and center of image reconstruction were at the discretion of the technologist.

For each image slice of each study, an estimated effective diameter of the patient was computed. A mean effective diameter over all the slices for each study was calculated.

In addition, for each slice of each study, the y-coordinate in mm of an in-plane center of mass cy was calculated by a center of mass equation weighted by Hounsfield Unit values, and adjusted for the location of
the center of rotation of the scanner derived from DICOM fields specific for the Philips scanner. A mean center of mass vertical position over all the slices for each study was calculated.

**Results**

The calculated mean effective diameters of the patients ranged from 21.3 cm to 44.8 cm (mean ± SD, 29.9 cm ± 3.7 cm). The mean CTDIvol values for the studies ranged from 3.4 mGy to 24.2 mGy (mean ± SD, 8.2 mGy ± 3.8 mGy).

The mean center-of-mass y-coordinate ranged from 3.7 cm to 6.7 cm (mean ± SD, 2.8 cm ± 1.2 cm), where positive values indicate the center of mass below the axis of rotation of the scanner; the results indicate that on average the center of mass was positioned slightly below the axis of rotation.

There was a slight tendency for smaller patients to be mis-centered lower than larger patients.

A scatter plot demonstrates a clear curvilinear relationship between mean CTDIvol vs. mean effective diameter. However, no clear relationship is seen between the mean CTDIvol and the center of mass y-coordinate.

A multiple regression analysis was performed to determine mean effective diameter and mean vertical positioning predicted mean CTDIvol for an abdominopelvic CT study. Based on the curvilinear form of the CTDIvol vs. mean effective diameter scatter plot (Figure 1), a quadratic term for mean effective diameter was added to the model. The regression provides an adjusted $R^2$ of 0.97. Although the regression coefficient for the center of mass vertical position was statistically significant (Figure 2), the value of the coefficient was nearly zero, indicating a practically negligible increase in CTDIvol with increasing distance of the patient center of mass below the center of rotation of the scanner (Figure 3).

*Figure 1*
The main motivation for this work came from preliminary observations with both patient and phantom data that did not support a significant change in CTD\textsubscript{vol} with changes in table vertical position on the Philips Brilliance 64 CT scanner. In order to more systematically evaluate patient vertical position in retrospective patient data, we calculated centers of mass from reconstructed images as detailed in the methods section.
We also retrospectively calculated the patient effective diameter using the reconstructed images, since we expect patient diameter to account for much of the variation in radiation output due to automatic tube current modulation.

Consistent with findings in previous reports[2, 4, 5], we found a tendency by our technologists to center the patient below the center of axis of the scanner in our study population. In addition, as has been reported previously[4], there is a slight tendency toward greater centering error in smaller patients.

We found that although there was a statistically significant correlation between patient centering and CTDIvol, the actual value of the regression coefficient was practically negligible, as most of the variance in CTDIvol produced by the automatic tube current modulation system could be explained by the effective diameter of the patient.

It should be noted, however, that the lack of change of CTDIvol with patient vertical centering does not imply that patient centering is unrelated to patient absorbed dose. CTDIvol is a standardized measure of the radiation output of a CT scanner without reference to the patient’s size, organ positions, and body composition[9]. Phantom studies have shown that patient mis-centering increases surface CTDI measurements in a manner that is not measured in volume CTDI measurements[6]. Since surface CTDI is not routinely measured in clinical CT, retrospective quantitation of patient mis-centering may provide an indirect measure of excess patient surface radiation not reflected in routine CTDIvol or DLP reporting.

An advantage of the centering assessment method used in this study is that it should be generalizable to any scanner regardless of the availability of lateral localizer radiographs. We suspect that calculation of the center of mass from volumetric data would be more accurate than calculation from localizer radiographs, though definitive demonstration may require evaluation of asymmetric phantoms with known center of mass.

Conclusion

We used a simple means of calculating both mean patient effective diameter and vertical center of mass position of patients from reconstructed CT images. Although there was an overall tendency to position the center of mass of the patient below the center of rotation of the scanner, the mean patient effective diameter accounted for most of the variation of mean CTDIvol among the scans in the study. Calculations of vertical patient position may nevertheless be of value by indirectly reflecting surface CTDI variability and image noise for the purposes of radiation dose reduction and image quality improvement.

References


Keywords

Computed Tomography, Radiation Dose, Body Imaging, Quality Control, Image Analysis