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Imaging Dose in Varian HyperSight™ CBCT Imaging System

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INTRODUCTION

The recently released Varian HyperSight™ is a CBCT plat form with fast acquisition time and superior image quality. In this study we examine the CBCT dose of HyperSight™ and compare it to other imaging methods.

AIM

On-board CBCT in image-guided radiotherapy has high clinical value. There is a risk that CBCT could deliver more dose to patients while producing inferior imaging quality than fan-beam CT (FBCT). The aim of this study is to report the imaging dose in a novel high-performance CBCT imaging system, Varian HyperSight™, with imaging quality comparable to FBCT.

METHOD

CTDI*vol* is reported as a weighted CTDI*100* taken at the central axis (C) and four peripheral locations in a cylindrical PMMA CTDI phantom with a 100-mm pencil ionization chamber[1]. Assumptions of this method are:

- The full dose profile, typically collimated up to 2cm in a fan-beam CT, can be fully captured by the 100-mm pencil ionization chamber
- The CTDI phantom can provide adequate thickness to achieve scatter equilibrium if the central slice of the phantom and pencil ionization chamber is positioned to align with the center of the collimation.

$$\mathrm{CTDI_{vol}} = \frac{1/3\ \mathrm{CTDI_{100,C}} + 2/3\left(\mathrm{CTDI_{100,T}} + \mathrm{CTDI_{100,B}} + \mathrm{CTDI_{100,R}} + \mathrm{CTDI_{100,L}}\right)}{\text{Reference Slit Width}} \times 100\mathrm{mm} \times \text{Profile Correction}$$

However, both conditions are not met in CBCT due to the cone-beam geometry, which can go up to 40cm in beam width[2].

To mitigate the underestimation of CBCT imaging dose, the IAEA's guideline[3] is followed by applying a correction factor to a weighted CTDI100 measured at a reference slit width of 2cm. The profile correction is obtained as the ratio of an accumulated in-air measurements with the pencil ionization chamber covering a 50cm longitudinal profile of uncollimated cone-beam to the in-air measurement at the reference collimation width.

$$\text{Profile Correction} = \frac{\text{slit width} \times \sum_{i=-n}^{n} \mathrm{CTDI}^{\text{in-air}}_{\text{iso}-i*100,\text{open field}}}{\mathrm{FS} * \mathrm{CTDI}^{\text{in-air}}_{\text{iso,slit width}}}$$

RESULTS

Sixteen measurements were taken with a mixed set of scanning parameters covering all clinical imaging protocols. CTDI*vol* was found to be correlated with exposure, with a coefficient of **0.0106**, **0.0227**, **0.0193**, and **0.026**6 for tube voltages of **80kVp**, **100kVp**, **125kVp**, and **140kVp**, respectively. The typical CTDI*vol* measured for chest (120kVp and 265mAs) and pelvis (140kVp and 210mAs) protocol with an FBCT are 7mSv and 10mSv, respectively, which are higher than 5.1mSv and 5.6mSv with HyperSight™. The measurements were within 5% of the reported CTDI except at a setting 80kVp and 50mAs (7.3% deviation). The mean deviation was 1.5%±2%.

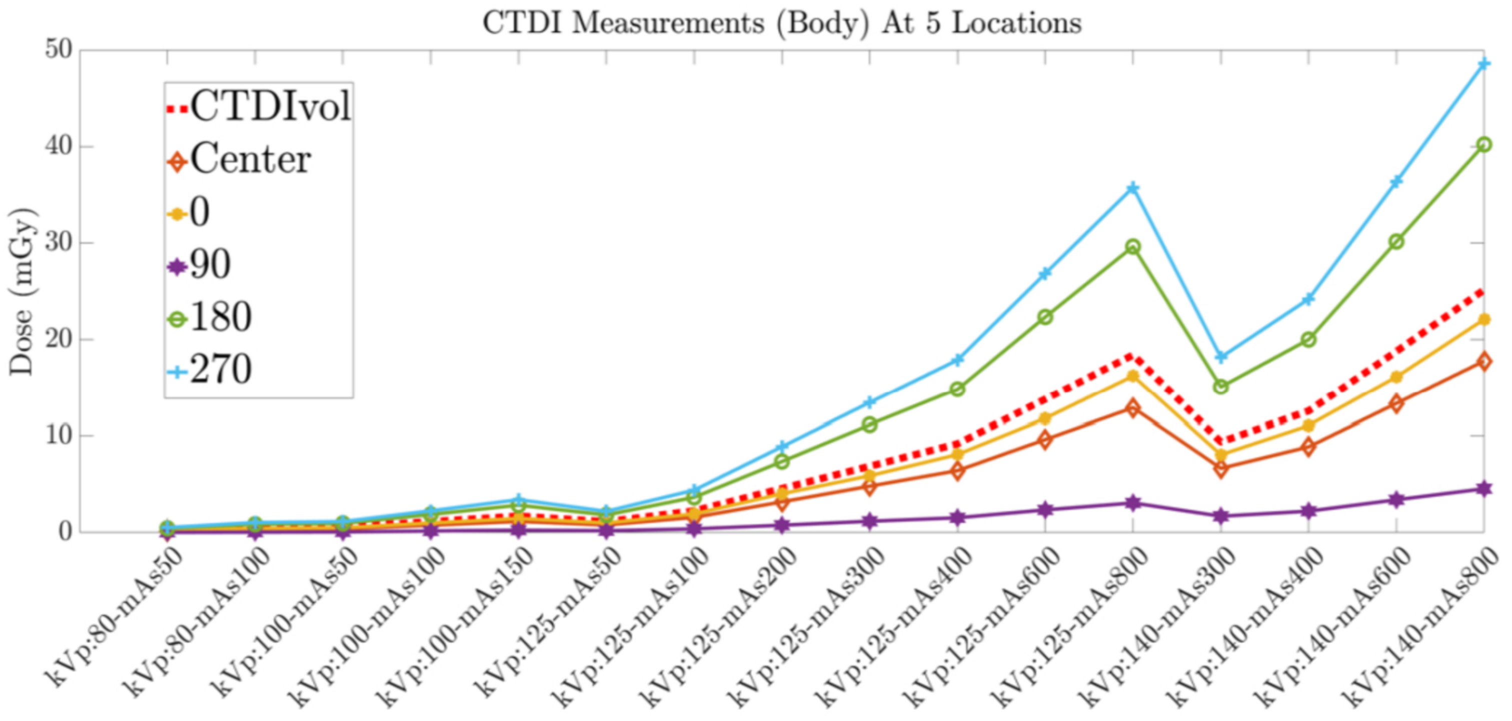

Figure 1. Distribution of imaging dose in the CTDI body phantom from the half-fan scan. Our measurement showed the imaging dose are significantly higher on the posterior (ogreen) and right (+blue) side than on the anterior (∗orange) and left (✶purple) side of a patient set up in the mostly common supine head-first orientation.

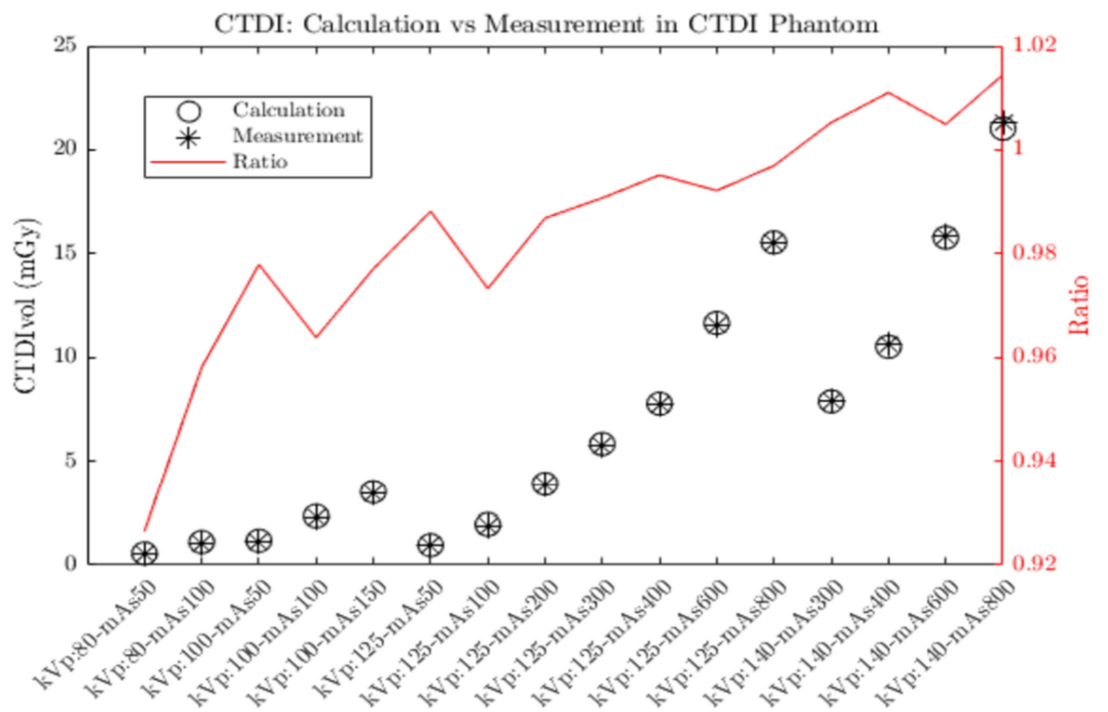

Figure 2. Comparison of CTDIvolbetween calculations provided by theHyperSight™CBCT imaging system (circles) and measurement (stars) in a CTDI phantom with RaySafe X2 system for a wide range of tube voltage and exposure-time combinations. The ratio of measurement to calculation (red) was plotted and labelled on the right axis.

CONCLUSIONS

When similar tube voltage and exposure are used, the image dose from the HyperSight™ CBCT is lower than that of FBCT, while maintaining similar image quality and fast image acquisition. It is a useful imaging tool for clinical use.

REFERENCES

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