Imaging Dose Evaluation of the Varian ProBeam CBCT Using Radiophotoluminescent Glass Dosimeters

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ABSTRACT

This study evaluated imaging doses from clinical CBCT protocols on the Varian ProBeam system using calibrated radiophotoluminescent glass dosimeters (RPLGD; GD-352M) placed in an anthropomorphic phantom representing head and neck, thorax, and pelvis treatment sites. Measurements were performed using the clinical Head, Thorax, Pelvis, and Image Gently protocols. Organ doses ranged from 0.8–1.9 mGy for the Head protocol, 3.9–4.7 mGy for the Thorax protocol, and 11.2–14.8 mGy for the Pelvis protocol, with higher doses observed for protocols using greater mAs. The Image Gently protocol reduced organ doses by approximately 70% compared with the Head protocol and by up to 98% compared with the Pelvis protocol. These results provide organ dose data for commonly used Varian ProBeam CBCT protocols and may support estimation of cumulative imaging dose during a proton therapy treatment course.

INTRODUCTION

Accurate patient positioning is critical in proton therapy, where range uncertainties increase sensitivity to setup errors; therefore, cone beam computed tomography (CBCT) is routinely used for image guidance. However, it also increases radiation dose to normal tissues. This study evaluated imaging doses from clinical CBCT protocols from the Varian ProBeam system.

METHODS AND MATERIALS

Radiophotoluminescent glass dosimeters (RPLGD), model GD-352M, were calibrated for air kerma using 70-kVp x-ray beam (HVL = 2.9 mm Al), with beam quality dependence accounted for 70–140 kVp (HVLs = 2.90–9.02 mm Al). Measurements were performed using RPLGD GD-352M placed in an anthropomorphic phantom representing head and neck, thorax, and pelvis treatment sites. CBCT scans were performed using the preset Varian ProBeam protocols shown in Table 1. Protocols were selected based on clinical practice, with Image Gently applied to the head and neck and pelvis regions for pediatric imaging.

RESULTS

Organ doses for the Head protocol are presented in Chart 1. The submandibular gland received the maximum dose (1.9 ± 0.4 mGy). Organ doses for the Thorax protocol are shown in Chart 2. The thyroid received the maximum dose (4.7 ± 0.2 mGy). Chart 3 summarizes organ doses for the Pelvis protocol, where the bladder received the maximum dose (14.8 ± 0.8 mGy). Overall, organ doses increased with increasing mAs. Compared with the Head and Pelvis protocols, the Image Gently protocol reduced organ doses by up to 70% and 98%, respectively.

Table 1. Preset protocol for ProBeam kV CBCT modes

CBCT mode	kV	mAs	$CTDI_{vol}$ (mGy)	DLP (mGy.cm)
Head	100	811	1.8	38.8
Thorax	125	1525	3.0	66.3
Pelvis	125	4633	9.3	201.5
Image gently	80	548	0.5	11.9

DISCUSSION

This study provides direct, organ-specific measurements of CBCT imaging doses for the Varian ProBeam system, for which quantitative organ dose data remain limited. The organ doses increased with increasing mAs, with the maximum doses observed for pelvic imaging. These data provided a practical basis for estimating total imaging dose and evaluating potential long-term risks, consistent with the recommendations of AAPM TG-180. The substantial dose reduction achieved with the Image Gently protocol highlights the importance of protocol optimization, particularly for pediatric patients.

The organ dose data reported in this study can assist clinicians in balancing image quality requirements with dose management and support informed selection of CBCT protocols in routine proton therapy practice.

CONCLUSIONS

This study provides organ doses for clinical Varian ProBeam CBCT protocols across multiple anatomical regions, enabling estimation of cumulative imaging dose over a treatment course.

REFERENCES

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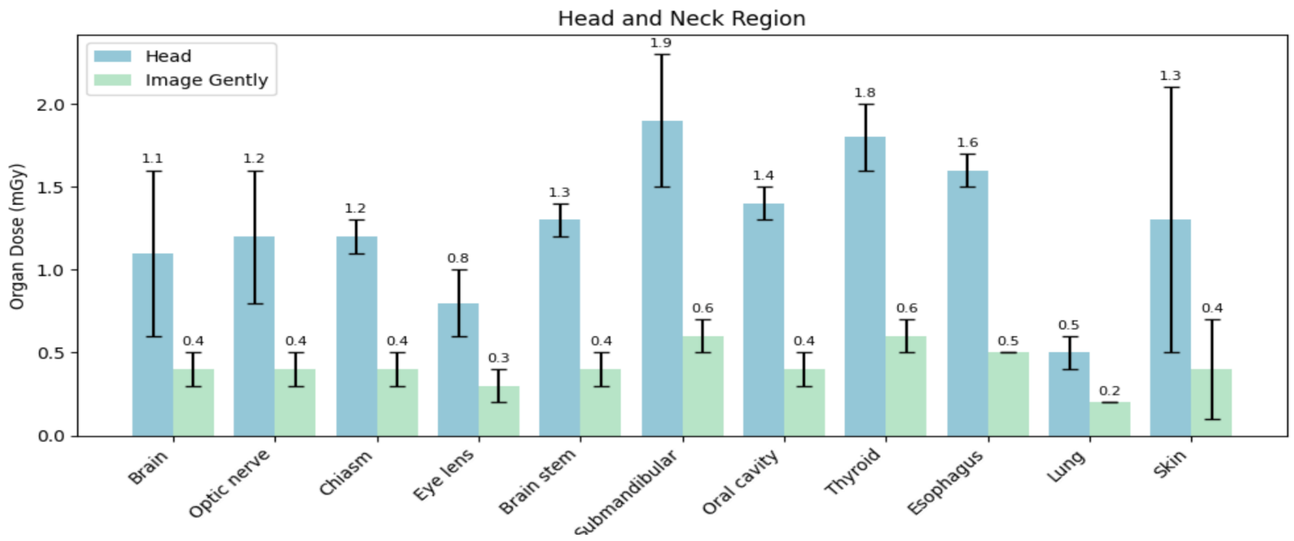

Chart 1. Organ doses for head and neck region using Head protocol of Varian ProBeam

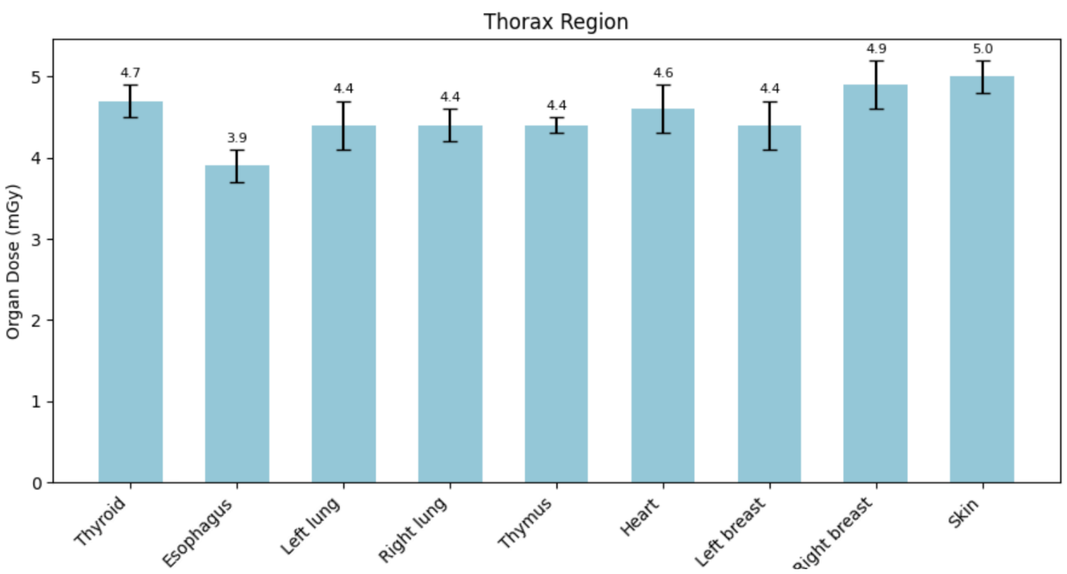

Chart 2. Organ doses for thorax region using Thorax protocol of Varian ProBeam

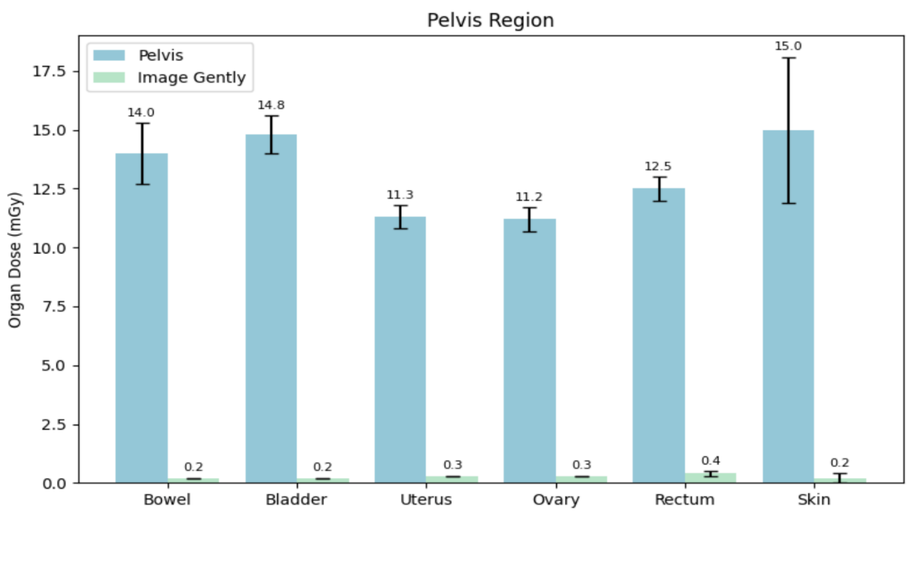

Chart 3. Organ doses for pelvis region using Pelvis protocol of Varian ProBeam

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