The influence of the Patient Size and Geometry on Cone Beam-Computed Tomography (CBCT) Hounsfield Unit (HU)

SP Heng, Sivamany Kandiyay
1. Radiotherapy Unit, Pantai Hospital Kuala Lumpur
2. University Science of Malaysia, Penang

INTRODUCTION

Kilo-voltage cone beam computed tomography (Kv-CBCT) has been widely studied for dose calculation in an adaptive radiotherapy. The accuracy of HU-CBCT based dose calculation is highly dependent on the accurate calibration of Hounsfield Unit to electron density (HU-HU). However, due to its large field of CBCT acquisition, the original CBCT Hounsfield unit calculated in the reconstruction varies significantly with patient size and geometry. Thus, the objective of this study is to present the influence of patient size and geometry to CBCT HU numbers and the CBCT dose calculation accuracy by using the patient-specific HU-HU mapping method to establish the relationship between the electron density of various tissues and their corresponding CBCT Hounsfield unit.

METHODS

In this study, two head and neck cases represent 13-year-old kid (Patient A) and 37-year-old adult (Patient B) nasopharyngeal carcinoma (NPC) patients were scanned with Elexis XVI system to acquire CBCT HU and CT HU; and two prostate cases were selected with respect pelvis thickness. Patient C had thickness less than 30 cm whilst patient D had thickness more than 30 cm and they were scanned to acquire CBCT HU and CT HU. All data were collected from routine clinical applications. Electron density-image sampling on the OMS XIO was used for HU-HU mapping known as patient-specific HU-HU mapping method. This method involves mapping the ED from planning CT to CBCT so that electron densities are equivalent in both systems. The accuracy of the patient specific HU-HU mapping method was validated by comparing dose distributions based on planning CT and CBCT datasets.

RESULTS

The HU-HU curves in Figures 1 and 2 illustrate the relationship between HU and relative electron density for these four patients with different size and geometry, large discrepancies were noted from these calibration curves. This suggests that a single CBCT HU-HU calibration curve will not be applicable to different patient size and geometry. Figures 3 and 4 show the comparisons of the IMRT isodose distributions for the patient B and patient C respectively. Almost similar isodose distributions were obtained by applying the patient specific HU-HU calibration curves to CBCT data sets; the doses computed based on planning CT data sets and CBCT datasets for both clinical cases agree to within 1% for planning target volumes and 3% for organs at risk.

This result showed good accuracy in CBCT based dose calculation with the patient specific HU-HU calibration curves created.

CONCLUSIONS

Our data show there is high dependence of Hounsfield Unit on patient geometry and less on size hence dose calculation on cone beam CT should be based on patient specific HU-HU calibration. There is significant differences between planning density dose calculation and CBCT dose calculation, the first day of CBCT data set rather than planning CT should be used as reference for the dose tracking. This ensures that calculated dose distributions and DVHs using CBCT images provide reliable dosimetric parameters comparisons.