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The Feasibility Study of Dual-Energy CT Virtual Non-contrast Instead of True Non-contrast in Proton Radiotherapy Dose Calculation

Xiaoxin Zuo[*], Jian Zhu[1], Guobin Qu[1]

[*,1] Department of Radiation Oncology Physics & Technology, Shandong Cancer Hospital of Shandong First Medical University, China

Objectives

To study the differences and correlations between true non-contrast (TNC) and virtual non-contrast(VNC) which is reconstructed from dual-energy CT (DECT), and to investigate whether cranial VNC can replace TNC in proton radiotherapy dose calculation.

Methods

TNC and VNC images of 40 patients were enrolled, including 20 brain, 10 chest and 10 abdomen, to investigate the differences between VNC and TNC. Firstly, home-made software was used to implement layer-by-layer subtraction of the two sets of images according to the Hounsfield Unit (HU) values, which was used to comprehensively observe the differences in HU values between VNC and TNC in 40 patients. The correlation of HU values at sites with significant differences were studied and the correction model for predicting TNC HU values from VNC HU values were established. Proton radiotherapy plans for 20 cranial tumors patients were designed to studied the effect of VNC instead of TNC in proton dose calculations.

Results

The differences between VNC and TNC were mainly concentrated in the areas containing bones, especially on skull and vertebrae. The mean HU values difference of the skull and vertebrae were 409.07±53.38 HU, 118.66±20.90HU, respectively. There was a significant association between the HU values of the VNC and TNC in skull and vertebrae in 40 patients (cranial: r=0.982, vertebral: r=0.991). The model established in this regard for predicting site-specific TNC HU values based on the VNC HU values was as follow: TNC=1.859×VNC+33.896 for cranial and TNC=1.827×VNC+5.491 for vertebral. There was a significant difference in the proton dose distribution on VNC and TNC images. The CTV, the 0.4cm region in front of the CTV and the 0.4cm region behind the CTV mean doses differed by 0.236%,1.803% and 3.561% between the two plans, respectively.

Conclusions

The differences between VNC and TNC are mainly concentrated in the areas containing bones, the skull and vertebrae are the most prominent. There is a strong connection between the HU values of the VNC and TNC in skull and vertebrae, and the TNC HU values can be predicted based on VNC HU values in these areas. For cranial patients, VNC is not appropriate to replace TNC for proton radiotherapy dose calculation.

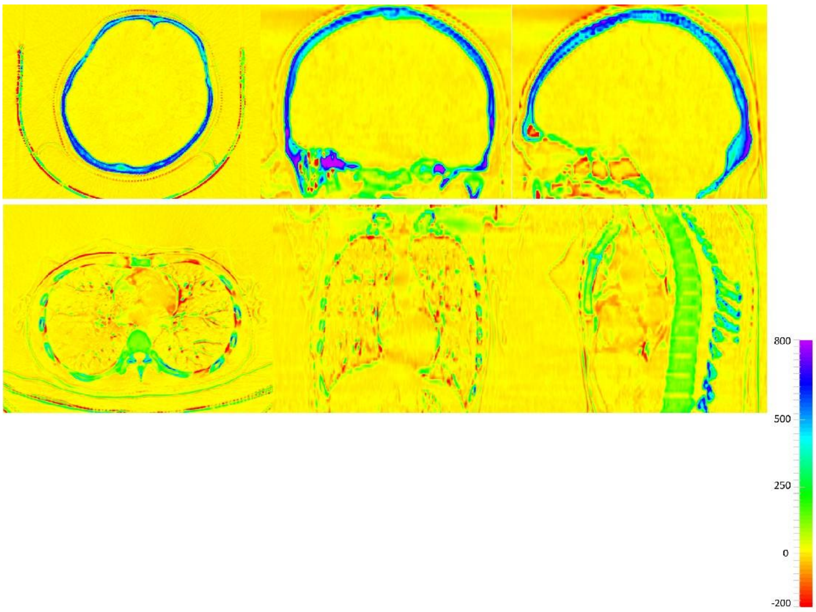

Figure1.Visualisation results of TNC and VNC at different sites by home-made software subtraction（TNC-VNC）.The blue and green areas represent large differences in HU values, and the yellow areas represent almost no differences in HU values.

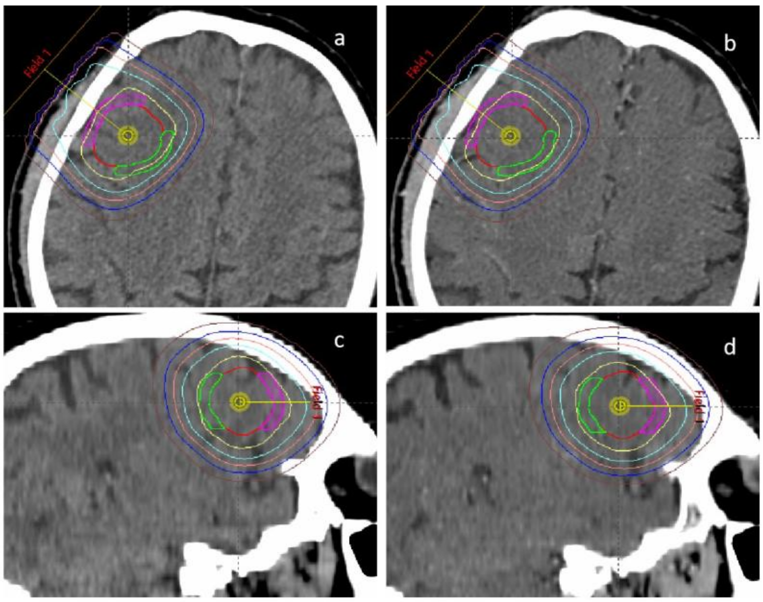

Figure2.The radiotherapy plans for TNC (a, c) and VNC (b, d) in a cranial patient.(a) and (b) are transverse slices; (c) and (d) are sagittal slices.The red area is CTV, and the purple and green areas are the 0.4cm expansion areas in front and rear the CTV.The yellow, cyan,pink,blue and brown isodose lines are 5040, 4356,4032, 3276, 2520, and 1008 cGy, respectively.

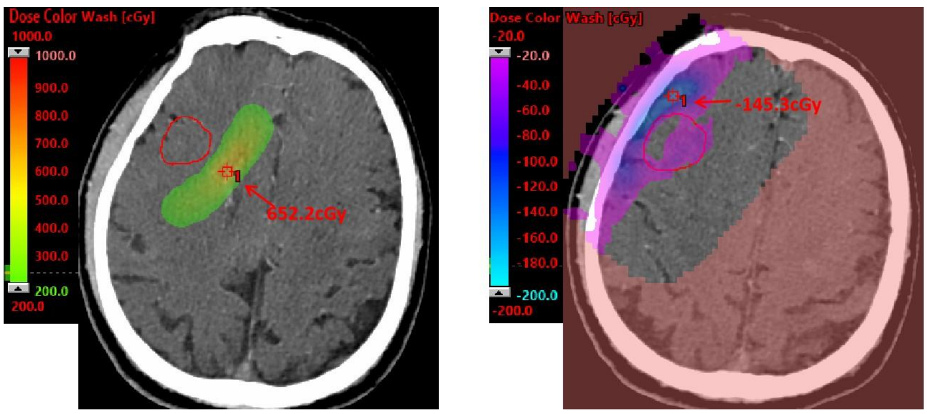

Figure3.Difference in dose distribution of the TNC and VNC proton radiotherapy plans