

The Calibration of CT Modeling for Proton Therapy Treatment Planning System

Theme: Physics

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Background / Aims:

CT images are the basis for proton therapy TPS. The calibration accuracy of their CT values against mass density/proton stopping power determines dose calculation accuracy, with errors from tissue substitutes. Proton/light ion CT calibration demands more than photons (due to different principles). Current methods like animal experiments get CT-SP curves, and a new study uses chemical composition measurement to improve accuracy.

Subjects and Methods:

This study employed the Mevion S250i proton therapy system, multiple CT scanners (Siemens and Philips models), the RayStation 10B treatment planning system, the CIRS 062M electron density phantom, and the Giraffe Bragg peak detector(IBA, Belgium). Tissue electron density, CT values, and relative stopping power were calculated via formulas. CT scans were performed under different conditions for modeling; the Giraffe detector was used to measure actual WET values. The modeling accuracy was verified by comparing WET values calculated by the planning system with the actual measured values.

Result:

Modules	Error (%)					
	Siemens Confidence		Siemens Definition		Philips Brilliance	
	120kVp	80kVp	120kVp	80kVp	120kVp	80kVp
Lung(Inhale)	-1.49	2.59	-0.10	2.78	-1.99	2.19
Lung(Exhale)	-1.15	-2.97	-1.25	2.37	-2.69	2.78
Breast Tissue	0.80	1.98	-1.35	-1.78	0.10	2.59
Liver	1.74	1.79	0.70	0.39	2.69	-0.99
Muscle	0.40	1.59	1.99	0.19	-0.55	-1.79
Adipose	-0.60	0.98	-0.60	-0.98	-2.49	1.00
Bone 200	1.05	-2.37	1.84	2.37	1.94	2.18
Bone 800	2.29	2.36	2.54	2.16	2.24	2.36
Bone 1250	-0.20	2.99	1.79	2.61	-1.25	2.15
Mean Error	0.32	0.99	0.62	1.12	-0.22	1.39

Table 1: The error (%) between the calculated WET values and measured WET values after calibrating the CT number-stopping power (CT-SP) curves of three CT scanners under different scanning conditions

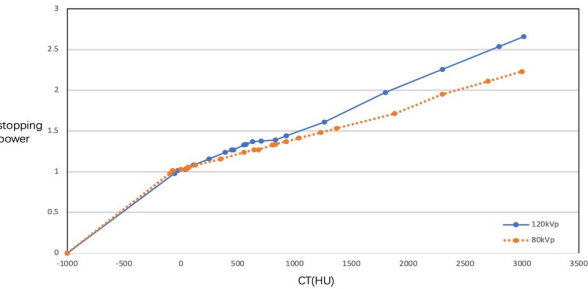


Figure 1: CT-SP curves of the Philips Brilliance CT scanner under different scanning conditions

Under the same/different scanning conditions, the CT values of tissue-equivalent modules of the three CT scanners showed differences (mostly <3%). The error of Water Equivalent Thickness (WET) of modules calculated by CT-stopping power (CT-SP) curves (calibrated via stoichiometric method) was significantly smaller than that by CT-mass density (CT-MD) curves. After manual calibration of the stopping power corresponding to high CT values, all errors were <3%. CT-SP curves are more suitable for proton dose calculation. Tube voltage has a great impact on CT modeling, while tube current has little effect. Clinically, it is necessary to match scanning conditions with modeling curves, and also pay attention to the CT value-stopping power conversion of unconventional materials.