What is the appropriate tolerance level of Hounsfield Units verifying CT scanner QA for treatment planning?

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INTRODUCTION

Since electron densities are an important factor for the correction of inhomogeneous media in radiation therapy planning, the tolerance levels of Hounsfield Units (HU) have to be verified by the annual-based CT scanner QA for radiation treatment planning[1-3]. In this study, the practical lower and upper tolerance HU levels are directly obtained from the calculated dose within ±1% variation using a treatment planning system (TPS). In addition, dose variations of clinical plans verify the measurements of HU values for the annual CT scanner QA.

AIM

To evaluate a tolerance level of Hounsfield Units of the CT scanner for radiotherapy treatment planning.

METHOD

1. An electron density phantom (GAMMEX RMI 465) was scanned using a CT scanner (GE LightSpeed).
2. In a treatment planning system (Varian Eclipse™ ver. 15.6), a 5 cm thick slab representing a different material was inserted in a virtual water phantom, 30 x 30 x 15 cm³.
3. Dose calculation was done using 6- and 15-MV photon energies: 10 x 10 cm² field size of at 10 cm depth with 100 cm source-to-axis distance. For each material, dose variation within ± 1% was calculated and its corresponding HU was estimated inversely to generate the lower and upper levels of HU values for both energies.
4. The tighter level was selected to represent tolerance levels of HU values of the relative electron density table.
5. In order to validate the dosimetry change from an inhomogeneous correction, two CT-density curves were generated using lower & upper tolerance levels.
6. Three clinical plans, head & neck, left lung, and prostate were tested to confirm the dosimetry changes.

RESULTS

Figure 1 shows 3D view of the 5cm thick slab phantom submerged in the water phantom. Result of the tolerance levels of Hounsfield Units verifying CT scanner QA for treatment planning is shown in Figure 2.

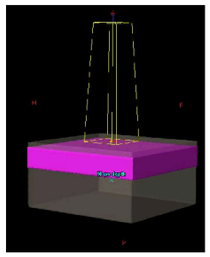


Figure 1. 3D view of the water phantom with a 5cm thick slab

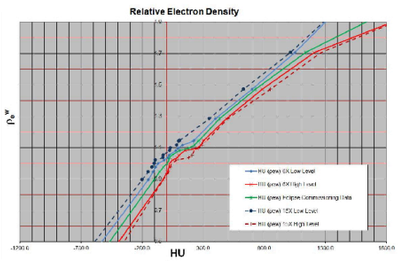


Figure 2. Result of tolerance levels of HUs verifying CT scanner QA for treatment planning

The dose variation from the lower and upper levels of relative electron densities were -0.70 ± 0.18% and 0.77 ± 0.22% for 6MV and 15MV photon energies, respectively. Using the newly-created CT scanners in terms of electron density curves, commissioning ± tolerance, the changes of mean PTV dose were 0.98% and 0.47%, 0.01% and 0.01%, and -0.31% and 0.45% for lung, prostate, and head & neck, respectively.

Table 2. DVH comparisons from the relative election densities vs. Eclipse ™ commissioning data

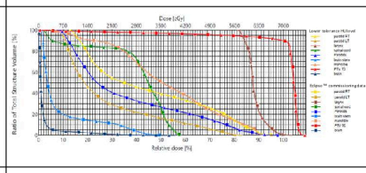
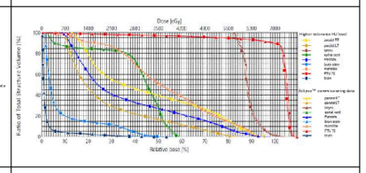
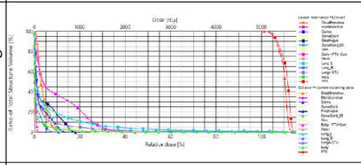
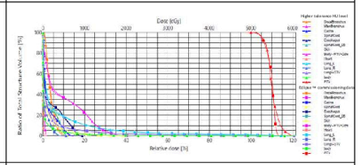
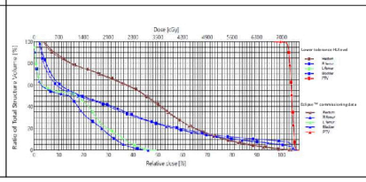
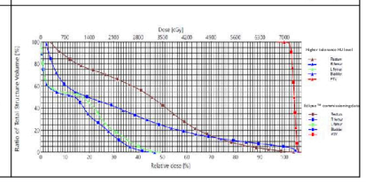
	Lower tolerance HU level Vs. Eclipse™ commissioning data.	Upper tolerance HU level Vs. Eclipse™ commissioning data.
Head and Neck		
Left Lung		
Prostate		

Table 1. The variations of the plan dosimetry between the lower & upper tolerance levels and Eclipse™ commissioning data.

Site	Structure	Mean dose (cGy) from Eclipse HU level	Mean dose (cGy) from Lower tolerance HU level	Mean dose (cGy) from Upper tolerance HU level	Dose deviation (%) (Eclipse HU vs Lower level HU)	Dose deviation (%) (Eclipse HU vs upper level HU)
Head & Neck	PTV	7057.60	7035.70	7092.00	0.31	0.49
	Spinal Cord	2806.30	2791.10	2829.20	0.54	0.81
	Brain Stem	608.20	607.10	610.70	0.18	0.41
Left Lung	PTV	5481.90	5536.30	5507.70	0.98	0.47
	Lung-GTV	186.70	185.40	188.20	0.70	0.80
	Left Lung	358.00	356.60	358.90	0.39	0.25
Prostate	PTV	7279.50	7279.50	7279.50	0.00	0.00
	Rectum	3040.70	3040.70	3040.70	0.00	0.00
	Bladder	2189.40	2189.40	2189.40	0.00	0.00

CONCLUSIONS

The tolerance levels for HUs of relative electron density data were evaluated from both 6MV and 15MV photon energies. The dosimetry variations between the lower and upper tolerance levels and Eclipse commissioning data for the three clinical plans, head and neck, left lung, and prostate, were evaluated as shown in Table 1. In addition, Table 2 shows detailed DVH comparisons for the plans. To maintain dose variation within 1% for both photon beams, it is recommended to keep a tighter tolerance level of HU of electron density curve as a part of the annual CT QA.

REFERENCES

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