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The Verification of the Monitor Unit Calculations

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Abstract

A comparison of the monitor unit calculations between a commercial treatment planning system (TPS) and "hand" calculations is extremely important in radiation therapy. In this paper, we will recalculate MU of the 3D-CRT plan for Lung and Rectal cancer on the treatment planning system supplied by Prowess Panther 4.6 at Dong Nai General Hospital, Vietnam. The monitor unit of each beams was recalculate by "hand" calculations and compared TPS. In general excellent overall agreement was found between calculations performed with the TPS and "hand" calculations. The MU difference between the monitor unit calculations of TPS and "hand" calculation was 0.144% with a standard deviation of 0.051% for rectal patients and 0.027 with a standard deviation of 0.008% for Lung patients. The result shows that there were no significant differences between recalculation and TPS.

Keywords: Linear Accelerator (LINAC); Monitor Unit Calculations; 3D-CRT

Introduction

Now a day, there are many accidents occur in radiotherapy because error in monitor unit calculations of TPS. In order to prevent accidents in radiotherapy, the monitor unit recalculations are a prerequisite component of quality assurance (QA) in radiation therapy. Because errors and large uncertainties in dose calculations reduce the quality of a treatment, MU recalculations have been recommended as a routine quality assurance (QA) procedure when verifying individual treatment plans [1]. Even though the validity of the calculation algorithms can be passed during the commissioning of a TPS, verification of the monitor units calculated by the TPS is typically performed using a "hand" calculation based all of standard beam data. In this paper we present a comparison of the monitor unit calculations of our planning system, panther 4.6 (Prowess Inc.) with "hand" calculations for Lung and Rectal cancer of clinical cases. The purpose of study was to evaluate the accuracy of a commercial radiation treatment planning systems.

Materials and Methods

Treatment planning

Lung and Rectal cancer is commonly seen in Vietnam. A plan was completed by a physicist, including an evaluation of the dose distributions and dose-volume histogram (DVH). All plans were created with a high energy level of 15MV photon (Primus, Siemens). The monitor units calculated using our treatment planning system, Prowess panther 4.6, are delivered for treatment (Figure 1).

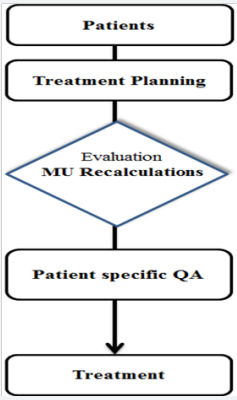

Figure 1: Flowchart of treatment planning.

A "hand" Calculations

The monitor units are verified using Microsoft office excel 2010 program which have the formalism described by Khan [2-5]. A general equation describing this calculation is as follows:

$$MU = \frac{D}{K \times CSF \times PSF \times ISC \times TPR \times OCR \times WF} \quad (1)$$

Table 1: The factors in this equation.

Factor	Symbol	Definition (dependence)
Output calibration	K	Dose in cGy/MU in calibration conditions. 1 cGy/MU at SAD for reference depth and field size.
Collimator scatter factor	CSF	Dose rate in air for a given collimator setting relative to that for the reference collimator setting (field size).
Phantom scatter factor	PSF	Dose rate at reference depth for a given field relative to that at the same depth for the reference field, using the same collimator setting (depth, field size).
Tissue phantom ratio	TPR	Dose rate at depth relative to dose rate at the reference depth for the same field size (depth, field size)
Wedge attenuation factor	WF	Attenuation due to transmission through physical wedge (depth, field size).
Off-axis ratio	OCR	Dose rate at off-axis position relative to dose rate at the central axis (off-axis distance)
Inverse square correction	ISC	Dose rate in air at prescription distance relative to that at standard SAD (depth+SSD)

D: Prescription dose

A ''hand'' calculations was based on the factors in table I and was used to verify the TPS calculation. The average dose difference between a ''hand'' and TPS calculations were given by the flowing formula:

$$\Delta = \frac{|a - X|}{X} \times 100\%$$

X: the number of MU TPS calculations

a: the number of MU a ''hand'' calculations

Results and Discussion

We analyzed these values for two common treatment sites. This verification is traditionally based on manual monitor unit (MU) calculation methods for 3D conformal radiotherapy (3D CRT) treatments. Tables 2 and 3 summarizes the average MU difference differences between the prowess panther and a hand calculation (equation 1).

Table 2: the factors and MU compare between TPS and recalculation for Rectum Cancer.

Beams / Factors	1	2	3	4
Prescription doseD (cGy)	52.600	52.600	52.600	52.600
Output calibration K (cGy/MU)	1.000	1.000	1.000	1.000
Collimator scatter factor CSF	1.000	1.001	1.000	1.000
Phantom scatter factor PSF	0.997	0.997	0.997	0.996
Inverse square correction ISC	1.061	1.061	1.061	1.061
Tissue phantom ratio TPR	0.869	0.766	0.965	0.765
Wedge attenuation factor WF	1.000	1.000	1.000	1.000
Off-axis ratio OCR	0.998	0.988	0.998	0.988
MU Prowess Panther	57.4	65.8	51.7	65.8
MU recalculation (1)	57.336	65.638	51.632	65.856
Average MU difference (%)	0.112	0.247	0.132	0.084

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Table 3: the factors and MU compare between TPS and recalculation for Lung cancer.

Beams / Factors	1	2	3
Prescription doseD (cGy)	57.400	76.600	76.600
Output calibration K (cGy/MU)	1.000	1.000	1.000
Collimator scatter factor CSF	0.987	0.986	0.989
Phantom scatter factor PSF	0.988	0.988	0.991
Inverse square correction ISC	1.061	1.061	1.061
Tissue phantom ratio TPR	0.765	0.970	0.858
Wedge attenuation factor WF	0.742	0.742	0.742
Off-axis ratio OCR	0.987	0.996	0.997
MU Prowess Panther	99	103.4	116.1
MU recalculation (1)	99.024	103.382	116.053
Average dose difference (%)	0.024	0.017	0.040

Case 1: Plan of rectum cancer

A plan was completed by a physicist, including an evaluation of MU. All plans were created with a high energy level of 15MV photon (Primus, Siemens). The number of beams and beam angles were 00, 900, 1800, and 2700 (Figures 2 & 3)(Table 2).

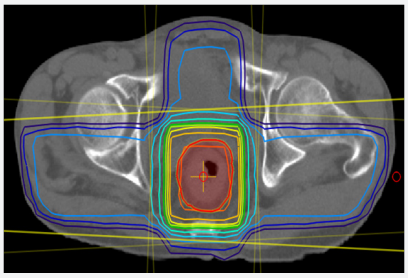

Figure 2: Treatment planning.

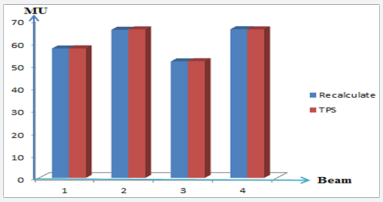

Figure 3: MU difference differences between the prowess panther and a hand calculation.

The results of this investigation show that the percentage difference is not significant. There isn't error in MU calculation of Prowess panther (Figures 4 & 5).

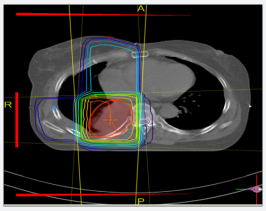

Figure 4: Plan of lung cancer.

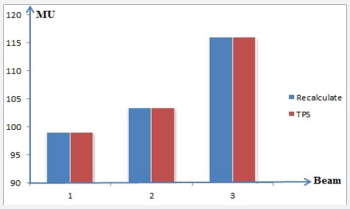

Figure 5: MU difference differences between the prowess panther and a hand calculation.

In general good agreement was found between calculations performed with the different TPSs and hand calculation.

Conclusion

The MU verification calculation should be performed before treatment by an independent physicist. Our calculation showed that 3D-CRT treatment plans were accurate for treatment delivery.

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