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Research Article

Influence of Dose Calculation Algorithm According to Dose Prescription Methods in Stereotactic Body Radiotherapy for Lung Cancer

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Abstract

Purpose: Prescribed doses for stereotactic body radiotherapy (SBRT) of lung tumors are defined as the minimum dose received by 95% volume of the planning target volumes (D95 dose prescription method) or the dose at isocenter (isocentric dose prescription method). At present, both dose prescription methods and various calculation algorithm are used for SBRT. With regard to SBRT for lung tumors, impact of dose calculation algorithm according to dose prescription methods was evaluated.

Material and Methods: For eight patients with lung cancer, SBRT plans with 6-10 fixed beams of 6MV photon were prepared. In the isocentric dose prescription method, 12 Gy was delivered to the isocenter. In the D95 dose prescription method, 10 Gy or more was delivered to 95% volume of the planning target volumes. Monitor units (MUs) determined by the D95 dose prescription method and the isocentric dose prescription method were calculated by both pencil beam convolution algorithm with Batho Power Law (BPL) and heterogeneity corrected anisotropic analytical algorithm (AAA) in each patient.

Results: The differences between MUs calculated by BPL and AAA were 0.6-7.5% (mean, 2.7%) for the isocentric dose prescription method, and 2.7-32.1% (mean, 12.2%) for the D95 dose prescription method (p=0.0176, paired t-test).

Conclusion: The differences of MUs according to calculation algorithm were larger in the D95 dose prescription method compared to the isocentric dose prescription method. In SBRT for lung cancer, differences of dose calculation algorithm should be noticed when the D95 dose prescription method is used.

Keywords: Stereotactic Body Radiotherapy; Dose Prescription; Calculation Algorithm

Background

Prescribed doses for stereotactic body radiotherapy (SBRT) were defined as the minimum dose received by 95% volume of the planning target volumes (D95 dose prescription method) or isocentric doses (isocentric dose prescription method). At present, dose prescription methods have not been unified. In the Radiation Therapy Oncology Group (RTOG) 0236 trial (A phase II trial of stereotactic body radiation therapy in the treatment of patients with medically inoperable stage I/II non-small cell lung cancer), 60 Gy in three fractions is delivered to 95% of the planning target volume. In Japan, isocentric dose prescription method was adopted in Japan clinical oncology (JCOG) 0403 phase II trial (a stereotactic body radiotherapy trial for stage I non-small cell lung cancer), while D95 dose prescription method was adopted in the JCOG 0702 phase I trial. Not only clinical trials but also clinical practice, both dose prescription methods are widely used in SBRT. Although Japanese Society for Radiation Oncology (JASTRO) guideline for SBRT recommends the isocentric dose prescription method in principle [1], there is a trend that dose prescription methods are changing from the isocentric dose prescription method to the D95 dose prescription method also in Japan.

In addition, a wide variety of algorithms for heterogeneity correction in dose calculation are used. Because of a variety of heterogeneity correction algorithms, it is difficult to compare outcomes among different institutions.

Monitor units (MUs) of radiation beams are calculated by variety of commercially-available calculation algorithm at present. Delivered MUs are affected by calculation algorithm. If differences of MUs calculated by different calculation algorithm are large, knowledge of optimal doses for tumors and normal tissue tolerance doses in SBRT will be confused. Because variety of calculation algorithm are commercially available at present, methods to decrease influences of calculation algorithm on MUs should be considered.

We examined the influences of calculation algorithm on MUs according to dose prescription methods in SBRT for lung cancer.

Material and Methods

For eight patients with lung cancer, SBRT plans with 6-10

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Table 1: MUs determined by isocentric dose prescription method (Isocenter dose = 12 Gy).

case	MUs by BPL	MUs by AAA	differences of MUs
1	1638	1628	-0.60%
2	1685	1674	-0.70%
3	1646	1769	7.50%
4	1821	1794	-1.50%
5	1619	1674	3.40%
6	1617	1706	5.50%
7	1511	1523	0.80%
8	1564	1591	1.70%
mean of absolute values = 2.7%			

Table 2: MUs determined by the D95 dose prescription method (D95 = 10 Gy).

case	MUs by BPL	MUs by AAA	differences of MUs
1	1409	1490	5.70%
2	1467	1506	2.70%
3	1425	1882	32.10%
4	1558	1667	7.00%
5	1417	1505	6.20%
6	1368	1695	23.90%
7	1329	1539	15.80%
8	1530	1591	4.00%
mean of absolute values = 12.2%			

fixed beams of 6MV photon were prepared. Delivered MUs were determined by the isocentric dose prescription method and the D95 dose prescription method. In the isocentric dose prescription method, 12 Gy was delivered to the isocenter in each fraction. In the D95 dose prescription method, 10 Gy or more was delivered to 95% volume of the planning target volumes in each fraction. Stereotactic body radiotherapy was performed with a linear accelerator (Clinac iX; Varian Medical Systems, Inc., Palo Alto, CA) and treatment planning was performed with treatment planning system of Eclipse (Varian Medical Systems, Inc., Palo Alto, CA). Monitor units (MUs) were calculated by the pencil beam convolution algorithm with Batho Power Law (BPL) and heterogeneity corrected anisotropic analytical algorithm (AAA) of Eclipse for both the isocentric dose prescription method and the D95 dose prescription method. Statistically significance of differences of averages was assessed by paired t-test.

Results

Differences between MUs calculated by BPL and AAA according to dose prescription methods. {(MUs calculated by AAA) / (MUs calculated by BPL) x 100} - 100 (%) were 0.6-7.5% (mean, 2.7%) for the isocentric dose prescription method, and 2.7-32.1% (mean, 12.2%) for the D95 dose prescription method (Table1,2). The differences of averages were statistically significant (p=0.0176).

Discussion

Both the isocentric dose prescription method and the D95 dose prescription method are used in SBRT for lung tumors in clinical practice. In addition, delivered MUs are calculated by variety of calculation algorithm for heterogeneity correction. Based on our results, MUs determined by the D95 dose prescription method was significantly affected by calculation algorithm compared to the isocentric dose prescription method. In the D95 dose prescription method, differences between MUs calculated by the D95 sometimes reached more than 20-30% according to calculation algorithms.

Because the lung is histologically heterogeneous organs contains air and small amount of soft tissues, dose calculation using different heterogeneity corrections results in different dose distributions.

It had been reported that the dose calculation algorithm was the most significant factor responsible for inter-institutional variations in planning for SBRT for lung cancer [2]. It was reported that different heterogeneity corrections have a marked impact on the dose distributions around the targets [3-7]. When pencil-beam algorithms compared to convolution superposition-type algorithms or the Monte Carlo algorithm, doses at the periphery of the planning target volume was overestimated with depending on the field size and the energy of the beam.

Based on our results, isocentric dose prescription method seemed to be preferable for inter-institutional comparison of treatment outcomes. When the D95 dose prescription method is used for lung SBRT, differences of dose calculation algorithm should be emphasized.

Conclusion

The differences of calculation algorithm influenced on MUs of lung SBRT largely when the D95 dose prescription method was used compared to when the isocentric dose prescription method was used. In lung SBRT, differences of dose calculation algorithm should be emphasized when the D95 dose prescription method is used.

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