Guideline for plan quality metrics in lung SBRT

David Pearson, Fatemeh Akbari, Somayeh Taghizadehghahremanloo
Department of Radiation Oncology, University of Toledo, Medical Center, 3000 Arlington Ave., Toledo, Ohio, 43614

INTRODUCTION

Stereotactic body radiation therapy (SBRT) is an excellent treatment option for early-stage non-small cell lung cancer as well as for managing metastatic lung tumours. SBRT involves precise delivery of few fractions of high dose of radiations to accurately delineated malignant targets. The quality of planned dose in SBRT can be evaluated by characterizing dose distributions for target coverage, homogeneity, conformity and gradient parameters.

AIM

The purpose of this study is to provide a guideline for the treatment plan quality based on ICRU 83 homogeneity, conformity, ICRU 91 Paddick and gradient indices (Paddick). We recommend these expected metrics ranges to be used to evaluate volumetric modulated arc therapy plans for lung SBRT when treated on a linear accelerator (linac) with 2.5mm multi-leaf collimator (MLCs).

METHOD

SBRT lung plans were calculated in RayStation with Collapse Cone (C.C.) algorithm and normalized to at least 95% of the planning target volume (PTV) receiving 100% of the prescribed dose. For all plans, prescription doses range were from 50 Gy to 60 Gy in 5 fractions. All lung SBRT cases were treated with 6-FFF or 10-FFF energies using Edge (Varian Medical System, Palo Alto, CA) with 2.5 mm high definition multi-leaf collimator (HDMLC). PTV volumes ranges were calculated while their geographic locations were distributed in both lungs.

All the data were categorized based on the target volume in three groups of small, medium and large sizes. We used Chi-Square test to ensure our data has a normal distribution being able to find outliers and exclude them from the statistical analysis.

For some case that the data was not normal, we used transformation. The transformed data had normal distribution properties which we tested again by chi-squared test and then identified the outliers.

RESULTS

Characteristics of patients included in this study along with tumour location are summarized in Table 1. The plan quality metrics calculated for the patient population in this study are shown in Table 2 to 5 along with max, min and average for Gradient, Conformity, Homogeneity and Paddick indices, respectively.

The mean target volume (PTV) was 15.19 (0.95−73.35) cm^3. At our clinic, we typically prescribe 10 or 12 Gy in 5 fractions for lung SBRT tumors. The PTV coverage in all patients was met in ≥95% of the prescribed dose.

For this study, the range of the recommended plan quality metrics is: Gradient (3.62−4.28), Conformity (1−1.06), Homogeneity (0.17−0.33), and CIPaddick (0.63 −0.89).

Table 1. Summary of study patient characteristics

Number		Tumor Location	
Male	39	RUL (Right upper lobe)	25
Female	26	RML (Right middle lobe)	5
Age average	71	RLL (Right lower lobe)	16
		LLL (left lower lobe)	8
		LUL (left upper lobe)	11

We used the following equations in order to calculate the plan quality indices:

RTOG Conformity Index (CI)= PIV/TV
PIV is the prescription Isodose volume, and TV is the Target Volume.

Gradient Index (GI)= $(PIV)_{50\%PIV}$/PIV
$(PIV)_{50\%PIV}$ denotes the volume of the 50% prescription Isodose.

ICRU Homogeneity Index (HI)= $(D_{2\%}- D_{98\%})/D_{50\%}$
$D_{2\%}$ and $D_{98\%}$ are dose received in 2% and 98% of the target volume, respectively.

Paddick conformity Index (PI)= $(TV_{PIV})^2/(TV \times PIV)$
TV_{PIV} is the volume of the target receiving the prescription dose.

Table 2: Gradient index ranges (smaller GI value is ideal)

	GI Min	GI Max	GI Median	GI Average	GI SD
Small V<10cc	3.620	7.220	5.090	5.292	1.049
Medium 10<V<30	3.470	5.970	4.475	4.587	0.762
Large V>30	3.310	4.280	3.84	3.760	0.314

Table 3: Conformity index ranges (CI value closer to 1 is ideal)

	CI Min	CI Max	CI Median	CI Average	CI SD
Small V<10cc	1.000	1.550	1.140	1.174	0.136
Medium 10<V<30	1.010	1.100	1.060	1.061	0.022
Large V>30	1.030	1.060	1.040	1.040	0.011

Table 4: Homogeneity index ranges (HI value closer to 0 is ideal)

	HI Min	HI Max	HI Median	HI Average	HI SD
Small V<10cc	0.170	0.430	0.330	0.321	0.059
Medium 10<V<30	0.160	0.430	0.325	0.312	0.069
Large V>30	0.260	0.330	0.280	0.290	0.024

Table 5: Paddick index ranges (PI value closer to 1 is ideal)

	PI Min	PI Max	PI Median	PI Average	PI SD
Small V<10cc	0.630	0.900	0.800	0.788	0.069
Medium 10<V<30	0.830	0.880	0.850	0.856	0.015
Large V>30	0.860	0.890	0.870	0.870	0.011

CONCLUSIONS

Sixty five patients diagnosed with lung SBRT in the year 2017 through 2020 were retrospectively reviewed and selected for this study. The obtained plan quality indices were in good agreement with similar published data. Evaluation of our data demonstrates GI becomes worse for the small PTV volumes of less than 10 cm^3; therefore, dose fall-off deteriorates. The correlation between PI and CI with target volume shows these indices improve with increasing the volume. Upon further evaluation, it was determined these two indices become worse for DIBH patient plans. Moreover, smaller lesions tend to have larger HI.

The provided data is valuable tools to ensure the plan quality in lung SBRT. We hope to improve standards by allowing centers to compare among each other. The provided data for each quality metrics is based on our analysis of clinically approved plans. These can be used as recommendations of acceptable plan quality for lung SBRT plans.

REFERENCES

- Yaparpalvi R, Garg MK, Shen J, Bodner WR, Mynampati DK, Gafar A, et al. Evaluating which plan quality metrics are appropriate for use in lung SBRT. Br J Radiol 2018; 91: 20170393.
- Shanmuga V. et al. Is 5 mm MMLC suitable for VMAT-based lung SBRT? A dosimter iccomparison with 2.5 mm HDMLC using RTOG-0813 treatment planning criteria for both conventional and high-dose flattening filter-free photon beams. Journal of Applied Clinical Medical Physics, Vol. 16, No. 4, 2015
- Christian Rønn Hansen, Anders Bertelsen, et al. Plan quality and delivery accuracy of flattening filter free beam for SBRT lung treatments. Acta Oncologica, 2015 54:3, 422-427

CONTACT INFORMATION

David.pearson2@utoledo.edu

Fatemeh.Akbari@rockets.utoledo.edu

Somayeh.Taghizadehghahremanloo@utoledo.edu