

Stereotactic Body Radiation Therapy (SBRT) Lung Cancer Treatment Plans Comparison Between HD MLC and Normal MLC

M Pudasaini¹, T Leventouri¹, S Pella^{1,2}, W Muhammad¹

(1) Department of Physics, Medical Physics, Florida Atlantic University, Boca Raton, FL, USA

(2) 21st Century Oncology, Boca Raton, FL, USA

INTRODUCTION

Stereotactic Body Radiation Therapy (SBRT) is a treatment modality that delivers high dose to the extracranial target volume in few fractions (2-5). SBRT is becoming common, not only because of the conformal high dose to the target, but also because of the very high dose gradient to spare normal tissue adjacent to the target. In SBRT:

- Multileaf collimators (MLCs) are employed to shape the beam to the target.
- In TrueBeams, the two MLC types available are with high definition (HD) MLC (2.5 mm leaf width) or with 5 mm MLC for the first 10 cm x 10 cm field size.
- Field size and the width of the individual leaves determine the conformity and steepness of the dose gradient.

AIM

The differences in dosimetric and radiobiological effects due to the use of these two types of MLCs is significant in lung treatment plans. The purpose of this research is to investigate the impact of high definition multi-leaf collimator (HD MLC) versus the normal multi-leaf collimator (MLC) on treatment plans of patients with lung lesions, who had been treated with Stereotactic Body Radiation Therapy (SBRT).

METHODS

A retrospective study of 25 SBRT treatment plans of patients were chosen from two cancer centers with TrueBeams, one with HD-MLC (2.5 mm width) and the other with the Normal MLC (5 mm width). 25 new plans were generated using the type of MLC that was not used in the treated plan, but with the same optimization parameters. The DVH data were used to calculate plan evaluation parameters.

Conformity Index (CI): $CI_{paddick} = \frac{V_{PTV} \times V_{PI5}}{(PTV_{PI5})^2}$

V_{PTV} is planning target volume, V_{PI5} is volume encompassed by prescription isodose surface, PTV_{PI5} is planning target volume encompassed within the prescription isodose surface

Heterogeneity Index (HI): $HI = \frac{D_{max} - D_{min}}{D_{mean}}$

D_{max} , D_{min} and D_{mean} are maximum, minimum and mean dose to the target volume.

Equivalent Uniform Dose (EUD): $EUD = (\sum_{i=1}^N v_i * D_i^a)^{\frac{1}{a}}$

v_i : the i'th partial volume receiving dose D_i in Gy.

a : A unitless parameter that describes the volumetric dependence of the dose-response relationship.

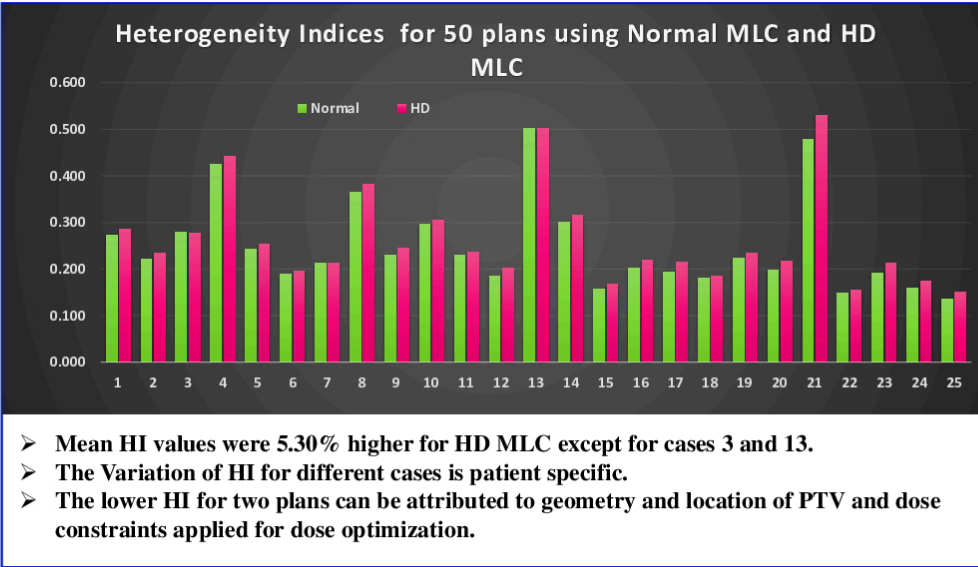
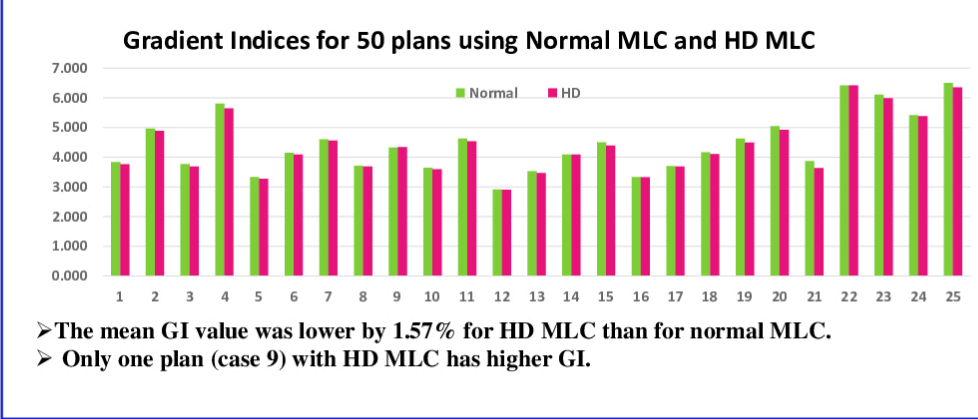
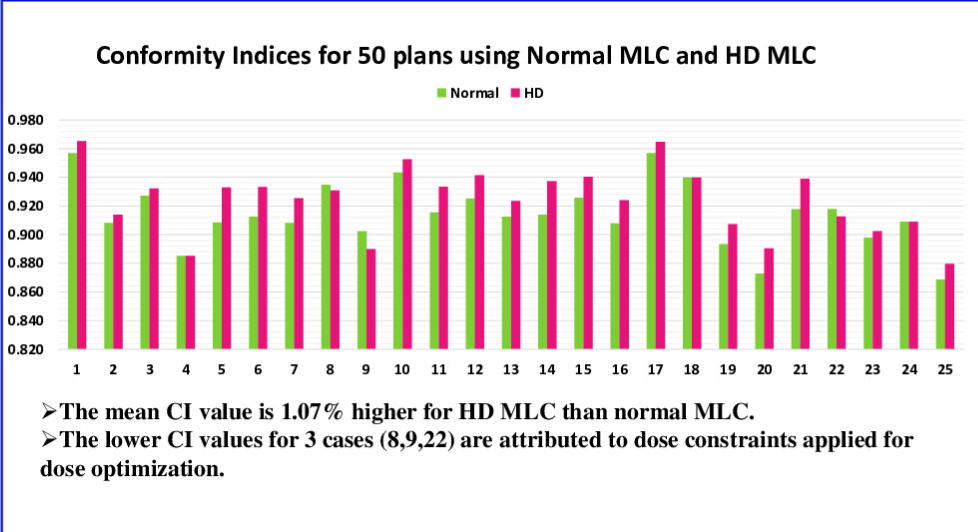
Normal Tissue Complication Probability (NTCP): $NTCP = \frac{1}{1 + [\frac{TD_{50}}{EUD}]^{4\gamma_{50}}}$

Tumor Control Probability (TCP): $TCP = \frac{1}{1 + [\frac{TCPD_{50}}{EUD}]^{4\gamma_{50}}}$

TD_{50} : tolerance dose for a 50 % complication rate,
 TCD_{50} : tumor dose to control 50% of the homogeneously irradiated tumors

γ_{50} : a unitless model parameter that is specific to the normal structure or tumor of interest that describes the slope of the dose-response curve

RESULTS



Indices	MLC	Mean	p-value
CI	Normal	0.914	0.132
	HD	0.924	
GI	Normal	4.440	0.804
	HD	4.371	
HI	Normal	0.248	0.645
	HD	0.262	

- p-values are higher than 0.05
- the indices are not statistically significant.
- For the HD MLC:
 - CI increased
 - GI decreased
 - HI increased

Structure	Quantity	Mean value for		p-value
		HD	Normal	
PTV	EUD	95.71	95.57	0.5488
	TCP	97.23	97.20	0.6830
Esophagus	EUD	21.25	22.30	0.0430
	NTCP	4.7	5.0	0.3250
Spinal cord	EUD	12.59	12.77	0.0228
	NTCP	1.7E-03	2.5E-03	0.3277
Heart	EUD	15.05	15.29	0.1247
	NTCP	5.2	5.3	0.1383
Contra-lateral lung	EUD	3.53	3.59	0.0014
	NTCP	1.7	1.8	0.2262

- The p-values for EUDs of Esophagus, spinal cord and contralateral lung are less than 0.05, so they have statistical significance.
- All other mean values are lower for OARs with HD MLC even though they are not statistically significant.

CONCLUSIONS

- The average CI value was increased by 1.07% for HD MLC while the average GI value was decrease by 1.57% for HD MLC.
- Dosimetric parameters were not found statistically significant, but still there is measured merit of HD MLC over Normal MLC in some cases.
- The maximum mean value of NTCP for OARs is found for heart and the minimum for the spinal cord among esophagus, spinal cord, heart and contralateral lung.
- EUD-based NTCP and TCP calculations did not show a significant difference for radiobiological effect of the two modalities however there is measured advantage of HD MLC in some cases.
- Further research with large cohort of patient cases with different sizes and locations of tumor is necessary to determine the conclusion.

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CONTACT INFORMATION

Mukunda Pudasaini
Department of Physics
Florida Atlantic University
Email: mpudasaini2013@fau.edu