A Study of Lung SBRT Dose Conformity Using a Simple Noncoplanar VMAT Technique

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INTRODUCTION

Purpose: In this study, we characterized dose conformity using a simple planning approach with a two-arc, two-objective, noncoplanar VMAT template for lung SBRT

- SBRT is a highly precise type of radiotherapy that uses high doses of radiation per fraction
- Sparing nearby OAR is maximized when plans are crafted with conformity and rapid dose fall-off as the main priorities
- Lung SBRT guidelines were initially defined in RTOG 0813
  - Main metrics are CI100% and CI50%
- We established a simple, planning template able to meet and exceed the conformity guidelines set by RTOG 0813 for lung tumors of diverse sizes and locations when OAR objectives were not an issue while adhering to institutional constraints

METHODS

- 288 lung SBRT clinical cases were replanned to 50 Gy using a simple, templated approach to study its effect on plan conformality
- Templates utilized two lateral 180° arcs separated by 30° couch angles, collimator angles were set to 45° and 315°, field size were automatically set using Arc Geometry Tool
- Plan clearance was assessed using a collision check software
  - If a collision was detected, minimal isocenter shifts were made to ensure a minimum of 2cm clearance
- One lower objective was added to the PTV and a custom NTO was used to steepen the dose gradient
- All plans were normalized to 95% of the prescription dose
- Dose conformity was evaluated for CI100, CI90, CI80, CI70, CI60, CI50, CI40, CI30, CI20, CI10 as well as dose to surrounding OARs

RESULTS

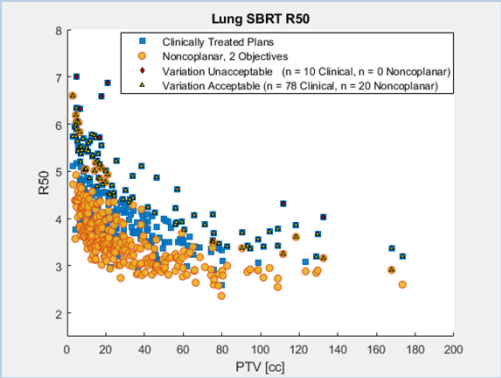
- Compared with the clinical plans, the two-objective VMAT plans achieved either similar or better OAR sparing with improvements in CI at the 10% - 100% isodose levels, which were all statistically significant ($p<0.001$).
- The average reductions in CI30% and CI50% were 3.5 and 0.63 respectively.
- Benchmarked against the clinical plans, cases exceeding RTOG CI50% limits were reduced from n=10 to 0 unacceptable variations and n=78 to 20 acceptable variations.
- Stepwise regression showed that CI50% increases as PTV mass density decreases and surface-to-volume ratio increases.

Dose Conformity (Isodose Volume/PTV)

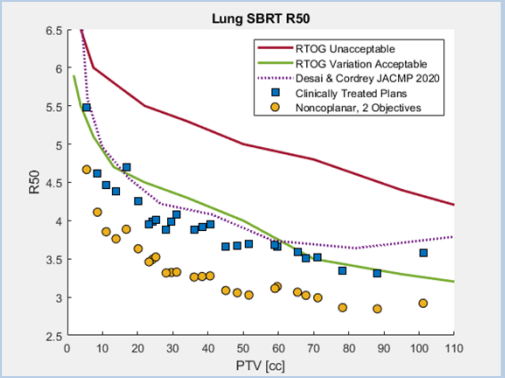
		CI100%	CI90%	CI80%	CI70%	CI60%	CI50%	CI40%	CI30%	CI20%	CI10%
Clinical Plan	Mean	1.03	1.37	1.73	2.21	2.95	4.21	6.68	12.4	27.2	61.17
	SD	0.08	0.16	0.24	0.35	0.52	0.83	1.49	3.39	9.65	30.09
NCP, 2 OBJ	Mean	1	1.28	1.6	2.01	2.61	3.58	5.3	8.89	19.34	57.59
	SD	0.04	0.08	0.16	0.25	0.4	0.65	1.1	2.08	5.22	24.16
Signed-rank test	p-value	7.34E-18	1.08E-25	6.40E-27	3.49E-31	2.20E-36	1.88E-42	1.97E-46	4.05E-48	4.36E-47	4.60E-06

Doses to Organs at Risk

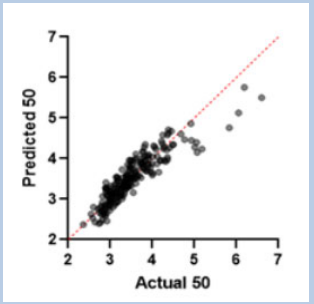
		Cord	Chest wall	Esophagus	Great Ves	Heart		Lungs		Trachea
		Dmax(Gy)	V30Gy(cc)	Dmax(Gy)	Dmax(Gy)	V20Gy(cc)	Dmax(Gy)	V12.5Gy(cc)	V20Gy(cc)	Dmax(Gy)
Clinical Plan	Mean	8.53	14.70	10.65	16.61	1.19	9.25	211.53	114.47	6.79
	SD	4.50	23.49	6.38	14.20	6.96	11.74	125.72	72.70	6.82
NCP, 2 OBJ	Mean	8.61	11.59	9.81	16.51	0.71	9.34	181.29	97.46	6.80
	SD	5.54	18.82	7.26	15.47	3.67	12.50	110.57	63.57	6.53
Signed-rank test	p-value	0.30	1.13E-25	3.64E-10	0.43	0.01	0.99	1.40E-35	3.00E-37	0.69



R50% of clinically treated (blue square) and noncoplanar, two-objective plans (yellow circle). Plans that were variation unacceptable/acceptable can be seen by red diamonds and green triangles, respectively.



Clinically treated plans and noncoplanar, 2 objective plans R50% averaged over an n=24 plotted against RTOG variation acceptable/unacceptable and the JACMP study.



Multiple linear regression predicting CI using multiple different factors. It was deemed that only HU and surface-volume ratio are consistently significant for all CI values shown above.

CONCLUSIONS

- A simple VMAT technique for lung SBRT planning was investigated and found to achieve conformal dose distributions. The CI50% model derived from this study could supplement the historic RTOG criteria to further improve lung SBRT dose conformity.
- The CI50% model generated by this study could supplement the historic RTOG criteria and further improve dose conformity in lung SBRT planning.

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