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Purpose/Objectives

- Megavoltage grid therapy has been shown to improve the local control of bulky tumors without any high-grade toxicity despite the high dose delivered in a single fraction.[1]
- We hypothesize that further local control could be achieved if a higher minimum dose is given to the target volume, similar to what is observed in brachytherapy, while the spatially-fractionated dose will help the repair of organs at risk.[2]
- This study aims to improve minimum target coverage by generating grid fields with inversely-optimized intensity-modulated grid fluences.

Materials/Methods

Delivery:

Grid plans are delivered using a linear accelerator with a tertiary collimator block (Figure 1) mounted orthogonally to the onboard multi-leaf collimation (MLC) system. With alternate MLC-leaf pairs closed, a grid pattern is produced. Furthermore, fluence of the opening grid can be modulated with multiple MLC segments.

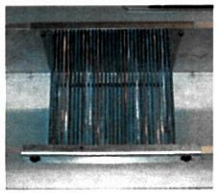

Figure 1: Picture of the collimation block.

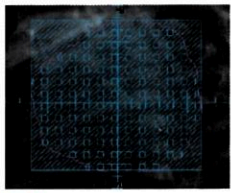

Figure 2: Beam's eye view of grid pattern on the target volume.

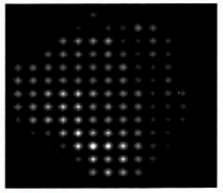

Figure 3: Optimized intensity-modulated grid pattern.

Optimization:

Plans were created with Pinnacle[3] v9.6 Radiation Therapy Planning Systems (Phillips Healthcare, Fitchburg USA). These intensity-modulated grid therapy (IMGT) plans were created using three orthogonal static-gantry beams, each possessing a grid-block (Figure 2) exposing just the planning target volume (PTV). Each of these beams were offset to maximize the coverage of the target volume. Fluence map optimization was performed on these beams. The fluence map of each beam (Figure 3) was then converted into deliverable MLC segments via custom made scripts.

Clinical Evaluation:

15 thoracic patients with large bulky tumors were used in the evaluation. Traditional single-field plans were created in addition to the three-field IMGT plans. Plan prescriptions were normalized so that 1% of the PTV receives at least 15Gy in the single fraction. Clinically relevant dose metrics were compared with Wilcoxon signed-ranked tests in SPSS (IBM Corp., Armonk, USA) to evaluate statistically significant differences.

Results

IMGT plans were able to significantly increase the minimum dose to the target volume. With the exception of the mean lung dose, IMGT was also able to either significantly reduce or maintain similar dose levels for OARs as the traditional single field plan.

	Lung V7.2Gy* (%)	Lung Mean (Gy)	Esophagus D0.1cc (Gy)	Esophagus Mean (Gy)	Heart Mean (Gy)	Cord D0.1cc (Gy)	Skin V16.9Gy* (%)	ntissue V10Gy (%)	PTV D99 (Gy)
1F Grid Average	5.02%	1.72	13.27	3.55	1.85	9.77	0.11%	0.84%	3.05
3F IMGT Average	4.95%	1.95	10.86	3.65	1.70	7.19	0.02%	0.53%	5.02
p-value[a]	.865	.015	.002	.394	.125	.008	.001	.016	.001

a. Wilcoxon Signed Ranks Test
*Values are BED of Lung V20Gy and Skin V65 using α/β ratios of 3

Table 1: Statistical results of the clinical evaluation

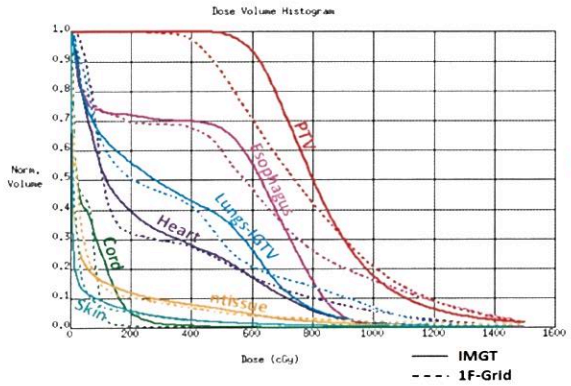

Figure 4: Dose-Volume Histogram comparing a single field grid plan (dashed) and a 3F IMGT plan (solid).

Conclusion

We have developed a prototype intensity-modulated grid therapy that can increase target volume dose coverage while reducing or maintaining the spatially-fractionated dose distributions to most of the surrounding organs at risk.

Future work will include validation of the doses using 3D-gel dosimetry and evaluating the effects of respiratory motion.

References

[1] Mohiuddin et al., IJROBP, 1999: **45**(3)
[2] Dimopoulos et al., Radiother Onc. 2009: **93**(2)

Acknowledgements

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