Rapid Delivery of GRID Therapy for Deep-Seated Bulky Tumors: A Novel 3D MLC-Based Forward Planning Treatment Technique via 10MV-FFF Beam

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INTRODUCTION

- Treating deep-seated bulky tumors with conventional single-field Cerrobend GRID-blocks has many limitations such as suboptimal target dose and excessive skin toxicity.
- Lifting of heavy traditional physical GRID-blocks poses a serious concern for patient safety at various slanted gantry-angles. [1, 2]
- Dosimetric detail is not readily available without a GRID template in user's treatment planning system.

AIM

To present our novel 3D MLC-based forward-planning technique [3] for rapid delivery of GRID therapy via flattening filter free (FFF) beams, providing ablative doses to bulky tumor using a brachytherapy-like dose tunnelling for the target and sparing adjacent critical structures.

METHOD

- Ten patient plans (4 head/neck, 3 chest, 1 para-spinal, 1 pelvis, 1 liver) were used retrospectively.
- Tumor sizes ranged 6.5-13.0 cm (mean, 9.5 cm).
- Standard Millenium120 MLC leaves fitted to gross tumor volume (GTV) generated 1 cm diameter holes and 2 cm center-to-center distance (at isocenter, similar to traditional single-field GRID-block), using an in-house algorithm.
- For a single-dose of 15 Gy, plans use 6-coplanar differentially-weighted 10MV-FFF beams at 60° spacing with 90° collimator rotation, generated dose tunnelling distributions without post-processing GTV-contours.
- Acuros-based dose was calculated in Eclipse.
- We evaluated GTVD50%, GTVD10%, GTV dose heterogeneities (peak-to-valley dose ratio, PVDR), dose to adjacent critical organs, maximum dose 2 cm away from the GTV (D2cm).
- Treatment planning and delivery time were recorded.

RESULTS

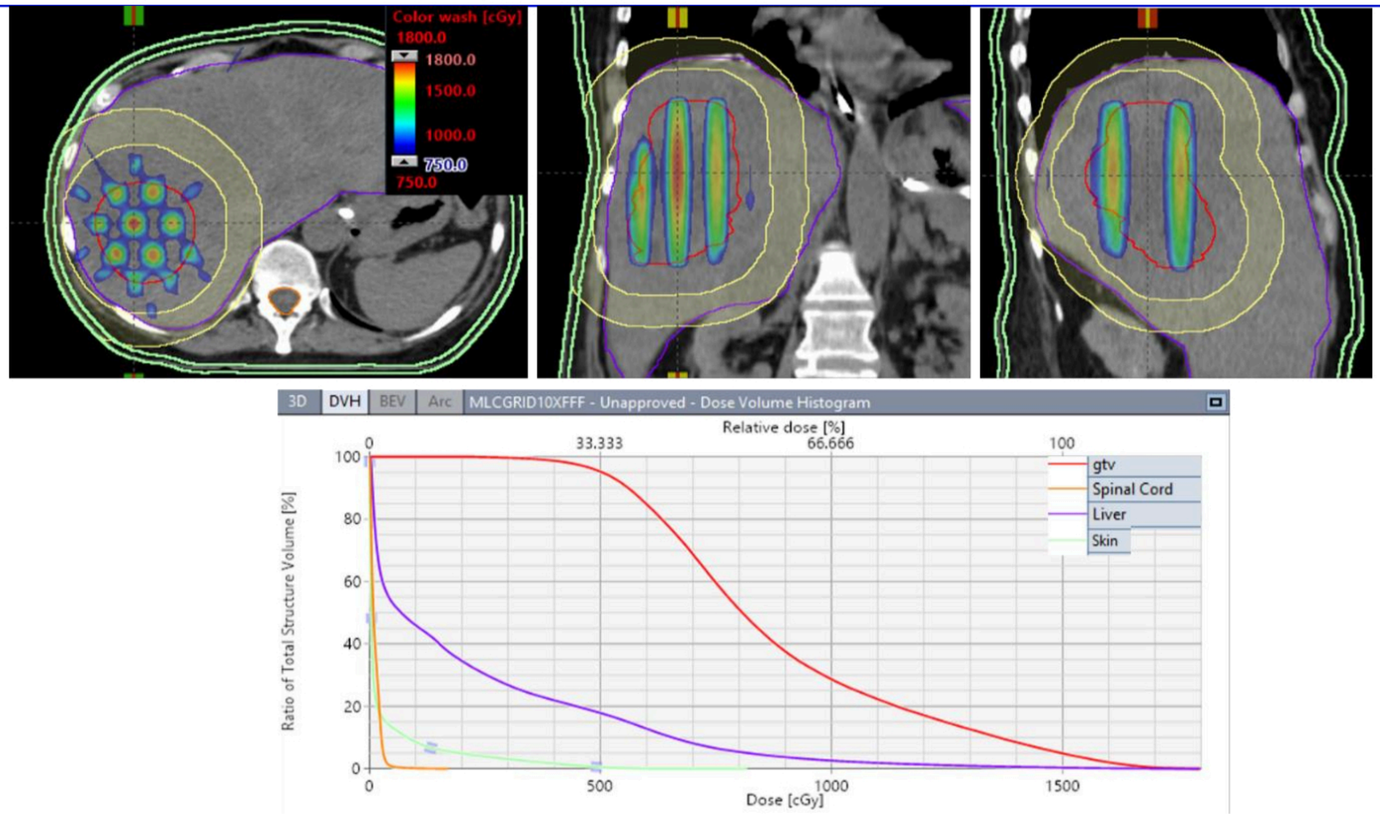

Fig. 1. *Axial, coronal and sagittal views of isodose colorwash for a GRID-therapy patient planned using 10MV-FFF (2400 MU/min) beam and 3D-MLC-based forward planning approach. Nominal prescription dose was 15 Gy in 1 fraction for a bulky liver mass of 8.0 cm in diameter (see red GTV contour). The GTVD50% and GTVD10% of 8.1 Gy and 13.2 Gy were achieved with D2cm of 68%. The PVDR was 2.9, by enabling escalated central tumor peak dose of 18 Gy (see cross-hair in above figure isodose colorwash, due to the characteristics of FFF-beam profile and a novel 3D planning technique). Maximum and dose to 5 cc of skin were 6.6 Gy and 5.3 Gy respectively. Immediately adjacent critical structures were spared including maximum dose to right kidney (< 3.8 Gy)*

- *Our 10MV-FFF (2400 MU/min) rapid GRID plans exhibited high mean GTVD50%, GTVD10% for 15 Gy of 8.2 ± 0.7Gy (range: 7.2–9.9 Gy) and 13.5±0.7 Gy (range: 12.4–14.6 Gy), respectively, escalating central tumor dose to 18 Gy.*
- *Average PVDR and D2cm was 3.1±0.3 (range: 2.7–3.8) and 69.1±10.6% (range: 58.4–87%), respectively.*
- *Averaged maximum and dose to 5 cc of skin were 11.4±3.2 Gy (range: 6.7–14.7 Gy) and 7.2±2.9 Gy (range: 1.2–10.4 Gy), respectively.*
- *Spinal cord (<6.0 Gy), heart (<5.5 Gy) and small bowel (<4.5 Gy) were spared.*
- *Average monitor units and beam-on time was 2306±174 and 1.01±0.1 min, respectively.*
- *Planning time was under one hour.*

SUMMARY/CONCLUSIONS

- This novel 3D MLC-based forward planning approach via 10MV-FFF beam generated brachytherapy-like dose tunneling distributions by utilizing cross-fires MLC fields.
- Our 10MV-FFF beam rapid GRID-therapy enhanced target dose for bulky tumors.
- It provided low dose to adjacent organs and including skin.
- This simple and fast FFF-GRID treatment can be easily adopted in any radiotherapy clinics.
- It provides detailed dosimetric information and could provide same day treatment for bulky masses by eliminating longer inversely-optimized planning and physics quality assurance time. [2]
- Rapid GRID delivery secures PVDR and potentially improves patient comfort and clinic workflow.
- Clinical validation of 10MV-FFF GRID therapy and radiobiological response of delivering rapid treatment is under investigation.

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REFERENCES

1. Meigooni A, Dou K, Meigooni N, *et al*, "Dosimetric characteristics of a newly designed grid block for megavoltage photon radiation and its therapeutic advantage using a linear quadratic model," Med. Phys. (2006); 33; 3165-3173
2. Wu X, Ahmed M, Wright J, *et al*, "On modern technical approaches of three-dimensional high-dose lattice radiotherapy (LRT)," Cureus (2010); 2:e9.
3. Damodar Pokhrel, Matthew Halfman, Lana Sanford, *et al*, "A novel, yet simple MLC-based 3D-crossfire technique for spatially fractionated GRID t therapy treatment of deep-seated bulky tumors, "J Appl Clin Med Phys (2020); 21:68–74

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