was irradiated with 20 Gy of X-ray so that an irradiated part and a non-irradiated part were formed. After X-ray irradiation, Free radical imaging by DNP-MRI was performed. In addition, T1-weighted MRI images were obtained.

Results: The EPR signal of Tempol capillaries were decreased depending on irradiation dose. In addition, a linear relationship between the spins of tempol radical and the irradiation dose was observed. The reduction rate of Tempol radical was 1.483/Gy. The gel phantom including Tempol radical was clearly visualized by DNP-MRI. Although the enhancement of gel phantom was observed in whole area before radiation treatment, the signal enhancement in half region (it is irradiated region by Linac) was decreased after radiation. In the T1-weighted MRI images, no signal change was observed between the X-ray irradiated part and the non-irradiated part. EPR signal of tempol in the capillary was decreased depending on radiation dose. Because hydroxyl radicals are generated by X-ray irradiation, Tempol was oxidized at first. After then, oxidized Tempol might be reduced by GSH in the gel phase. On the other hand, DNP-MR imaging of the phantom with radiation treatment was clearly visualized the site of the free radical reaction between Tempol/GSH gel with ROS. It is suggesting that the Tempol/GSH gel phantom would be useful for the redox sensor for radiation treatment.

Conclusion: The distribution of free radical generation produced by X-ray irradiation was visualized by DNP-MRI with Tempol/GSH phantom.

Author Disclosure: **N. Koyasu**: None. **F. Hyodo**: None. **R. Iwasaki**: None. **T. Mori**: None. **T. Yamaguchi**: None. **M. Matsuo**: None.

2861

SIMSEB: Unlocking the Dosimetric Potential of Sequential Boost Plans in VMAT Through Simultaneous Optimization

R.H.J. Fick, T. Boule, A. Pouille, A. Lombard, N. Bus, and N. Paragios; *Therapanacea, Paris, France*

Purpose/Objective(s): Radiotherapy often comprises an integrated or sequential dose escalation to a smaller volume containing the gross tumor volume. Sequential boost (SEB) and simultaneously integrated boost (SIB) plans differ in that in SEB the dose escalations are optimized and delivered sequentially (fraction-variant delivery), while in SIB they are optimized and delivered jointly. Many studies point out the dosimetric benefits of using SIB over SEB based on retrospective planning (e.g. Farzin et al. 2015), but we argue that it is the separate optimization process that is blunting the dosimetric potential of SEB - not the planning approach itself (Popple et al. 2005). To overcome this limitation, we introduce a novel optimization framework for the simultaneous optimization of sequential boost plans (SIMSEB) in VMAT. SIMSEB jointly optimizes multiple separate dose volumes, accounting for the sequential boost dose prescriptions, while dose constraints on organs at risk (OARs) are accounted for on the cumulative dose of all boosts. Owing to the larger optimization space, we show that SIMSEB can actually achieve better dosimetry compared to SIB plans with the same planning objectives.

Materials/Methods: We retrospectively plan 20 prostate cases using either SIB or SIMSEB VMAT optimization. Included PTV2 objectives were a 50Gy prescription to the prostate bed and a 30Gy boost PTV1 to the prostate. Standard OAR planning goals were used (see Table), and PTV-ring structures were added to improve dose conformity. Single-arc SIB-VMAT is optimized with OARs and both PTVs (PTV50 and PTV80) in the same dose volume. Single-arc SIMSEB-VMAT simultaneously optimizes the two sequential boost PTVs (PTV50 and PTV30boost) with OARs cumulatively receiving dose from both dose volumes.

Results: We compare the dosimetry of both approaches based on PTV homogeneity and conformity index (HI and CI) and OAR-DVH values. The table shows SIMSEB obtaining significantly better CI and HI for both PTVs compared to SIB, along with somewhat lower OAR DVH values.

Conclusion: The results show that SIMSEB shows promise to improve the dosimetric potential of SEB plans, allowing for the joint optimization of fraction-variant, partially overlapping planning objectives and structures. SIMSEB's dosimetric advantage is explained by SIMSEB allowing more fluence modulation over multiple boost plans compared to SIB's integrated single plan. We note that the SIMSEB approach can be generalized to optimize any fraction-variant planning approach, taking into account predicted treatment response like tumor growth or other radiobiological tumor properties over time.

Abstract 2861; Table

Structure	Quantity	SIB	SIMSEB
Bladder	V60<50	6.2±4.7	7.1±5.1
	V70<25	2.7±2.3	2.8±2.3
Femoral Head L	V50<10	0.07±0.27	0.03±0.05
Femoral Head R	V50<10	0.01±0.03	0.02±0.06
Rectum	V60<50	8.0±5.6	7,2±4.8
	V70<25	3.0±3.0	2.8±2.4
	V74<05	1.8±2.1	1.2±1.4
PTV1 (80Gy / 30Gy boost)	HI	0.23±0.08	**0.14±0.01**
	CI	1.39±0.54	**1.05±0.20**
PTV2 (50Gy)	HI	0.16±0.08	**0.12±0.01**
	CI	1.05±0.06	**1.03±0.1**

Author Disclosure: **R.H. Fick**: None. **T. Boule**: None. **A. Pouille**: None. **A. Lombard**: None. **N. Bus**: None. **N. Paragios**: Stock; Therapanacea. CEO; Therapanacea.

2862

A Novel 3D MLC-Based Forward Planning Technique for Spatial Fractionated GRID Therapy

D. Pokhrel,[1] L. Sanford,[1] M. Halfman,[1] M.E. Bernard,[2] W. St. Clair,[1] M.E. Randall,[1] and M.R. Kudrimoti[2]; [1]*University of Kentucky, Lexington, KY,* [2]*University of Kentucky Department of Radiation Medicine, Lexington, KY*

Purpose/Objective(s): To present a novel and clinically useful 3D MLC-based forward planning technique for GRID therapy that provides fast, safe, and effective treatment delivery of larger ablative doses to deep-seated bulky tumors.

Materials/Methods: Seven patients (3 head and neck, 1 chest, 1 breast, 1 para-spinal, 1 pelvis) with 7.0 to 12.0 cm diameter tumor sizes were treated using our novel MLC-based 3D-GRID therapy in our clinic. Standard Millenium120 MLC leaves were fitted to gross tumor volume (GTV) to generate 1 cm diameter holes and 2 cm center-to-center distance (at isocenter) mimicking traditional GRID-block pattern using an in-house algorithm. For a single-dose of 15 Gy, 3D MLC-based GRID plans were generated using 6-coplanar gantry positions at 60° spacing (210 ° to 150 °) with 90° collimator rotation for a differentially-weighted 6−18MV beams. This MLC fitting algorithm in treatment planning system generates brachytherapy-like dose tunneling distributions without post-processing GTV-contour. Advanced Acuros-based dose was calculated. Dosimetric parameters evaluated include: GTVD50%, GTVD10% (hottest 10% of the GTV), GTV dose heterogeneities (peak-to-valley dose ratio, PVDR), skin dose, dose to immediately adjacent critical structures, and maximal dose 2 cm away from the GTV (D2cm). Additionally, planning time and delivery efficiency was recorded.

Results: All 3D-MLC GRID plans exhibited excellent target dose with mean GTVD50%, GTVD10% of 15 Gy being 7.5 ± 0.4 Gy (range: 7.4−8.3 Gy) and 12.4 ± 0.4 Gy (range: 11.2−12.9 Gy) or higher, respectively. Average PVDR and D2cm was 2.9 ± 0.5 (range: 2.5−3.8) and 64 ± 11% (range: 53−78%), respectively. Maximal and dose to 5 cc of skin were 10.6 ± 3.6 Gy (range: 5.5−13.1 Gy) and 6.5 ± 3.2 Gy (range: 2.6−10.5 Gy), on average, respectively. Immediately adjacent critical organs were spared: spinal cord (< 5.2 Gy), heart (< 5.7 Gy), femoral head (< 6.7 Gy) and small bowel (< 4.5 Gy). Average total monitor units and beam-on time was 1975 ± 93 and 3.3 ± 0.2 min, respectively. Overall treatment planning time was about an hour.

Conclusion: This novel and clinically useful 3D MLC-based forward planning approach for GRID-therapy resulted in enhanced target dose for deep-seated bulky tumors, low skin toxicity and low doses to adjacent critical organs. This simple and fast MLC-based GRID therapy can be