



Contribution ID: 30

Type: Oral

Robust dynamic-collimator trajectory radiotherapy (colli-DTRT)

Thursday 30 November 2023 14:30 (10 minutes)

Purpose: To develop robust dynamic-collimator trajectory radiotherapy (colli-DTRT), including robust dosimetrically motivated path-finding, to manage patient set-up uncertainties.

Methods: colli-DTRT plans were created for one brain (30 x 2 Gy) and one breast (16 x 2.65 Gy) clinically motivated cases. colli-DTRT paths were generated through iterative fluence map optimization (FMO) and beam angle elimination. Direct aperture optimization (DAO) was applied to the paths to obtain a deliverable plan. Standard planning target volume (PTV) plans (colli-DTRT_{PTV}) were optimized using a PTV extending the clinical target volume (CTV) by 3 mm (brain) and 5 mm (breast). Robust plans (colli-DTRT_{robust}) were optimized directly on the CTV using robust FMO during path-finding and robust DAO for final plan optimization considering 5 mm systematic shifts in all three directions. All plans were normalized to 50% of the PTV/CTV. Plan quality and robustness were evaluated by comparing dose-volume endpoints of the nominal scenario and the standard deviation (σ) of the mean over all scenarios.

Results: For the brain case, $D_{98\%}$ to the CTV was 58.0 Gy ($\sigma = 1.1$ Gy) for colli-DTRT_{PTV} and 57.3 Gy ($\sigma = 2.2$ Gy) for colli-DTRT_{robust}. $D_{2\%}$ to the right optic nerve was 38.1 Gy ($\sigma = 10.5$ Gy) for colli-DTRT_{PTV} and 32.5 Gy ($\sigma = 6.0$ Gy) for colli-DTRT_{robust}. For the breast case, $D_{98\%}$ to the CTV was 41.0 Gy ($\sigma = 0.3$ Gy) for colli-DTRT_{PTV} and 40.6 Gy ($\sigma = 0.3$ Gy) for colli-DTRT_{robust}. D_{mean} to the right lung was 12.2 Gy ($\sigma = 0.9$ Gy) for colli-DTRT_{PTV} and 11.8 Gy ($\sigma = 0.8$ Gy) for colli-DTRT_{robust}.

Conclusion: Robust colli-DTRT with robust dosimetrically motivated path-finding was successfully developed, improving organs at risk sparing and robustness compared to the PTV approach for two investigated cases. However, target coverage was higher in colli-DTRT_{PTV} than colli-DTRT_{robust} for both cases. Robustness of target coverage was the same for the breast case but better with colli-DTRT_{PTV} than colli-DTRT_{robust} for the brain case.

Disclosures: Supported by SNSF grant 200021_185366 and Varian Medical Systems.

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Session Classification: Session II

Track Classification: Radiation Therapy