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Determining Changes in Organ Sparing with Increasing Target Dose Heterogeneity for Pancreatic SBRT VMAT

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Abstract

Objectives: This study aims to retrospectively evaluate the changes in dose gradient affecting normal tissue organ dose as a result of increased target dose heterogeneity for pancreatic Stereotactic Body Radiation Therapy (SBRT) patients treated with Volumetric Arc Therapy (VMAT) radiation therapy. Our initial hypothesis was that increasing dose heterogeneity would yield a favorable gradient index.

Methods: 10 patients previously treated with radiation therapy for pancreatic cancer were selected as volumes for creating new plans of varying dose heterogeneity. For each patient, 10 plans were created using VMAT inverse optimization to simulate pancreatic SBRT, with an upper dose constraint placed on the duodenum. Each plan was optimized with an incrementally increased allowed maximum dose to the target volume, from a 105% to 180% hotspot. Its effect on the gradient index and normal tissue dose was analyzed to find the relationship between heterogeneity and plan quality.

Results: A total 100 VMAT plans with varying levels of target dose heterogeneity were evaluated. Contrary to our initial hypothesis, organ sparing does not continuously improve as target dose heterogeneity increases for VMAT treatments. The most conformal plans delivering favorable normal tissue organ dose were created when a hot spot of 120% - 130% is allowed within the target. While maximum dose to the duodenum asymptotically decreased with increased dose heterogeneity, the mean dose to the duodenum increased after 130% heterogeneity among all plans in this study. Plans created with higher heterogeneity exhibited up to a 10% increase in gradient index and adjacent normal tissue mean dose, as well as significantly higher plan Monitor Units (MU).

Conclusions: While the hypothesis that a more relaxed upper dose constraint will yield plans with lower normal tissue dose is intuitive, the data collected in this study shows that the increase in allowed dose to the target does not always mean a decrease in the gradient to the normal tissue. This is likely because enforcing some homogeneity on the target and optimizing the maximum dose it receives would limit dose spillage in the surrounding tissue, and also mitigate the MU of the optimized plan. There appears to be a sort of "sweet-spot" when it comes to target heterogeneity, where the is enough flexibility in the maximum dose objective for the optimizer to focus on reducing OAR dose, but enough strength to minimize dose within the patient.

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