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Automated Stereotactic Radiosurgery Planning Enables Accurate a Priori Fractionation Scheme Selection via Adherence to HyTEC Toxicity Thresholds

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Abstract
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Abstract

Objectives:

Radiosurgery plan safety is estimated via particular brain volumes receiving specific doses (i.e., 12Gy/1fx), which are only evaluated post plan generation. However, automated planning can produce highly consistent, and thus predictable, plans. Here, we hypothesize that HyperArcTM (HA) automated SRS planning enables clinical decision-making prior to plan generation—such as choosing between SRS or conventional treatment, or selecting the appropriate SRS hypofractionation scheme. We present, to the authors' knowledge, analysis of the largest-ever SRS dosimetry cohort.

Methods:

Our institution's entire database of clinically treated single-isocenter HA plans was queried, totalling 2700 targets (1241 plans) without 50% isodose volume (IDV) bridging. Seven IDV (50.00%-81.33%) were calculated for all HA targets, corresponding to ratios of HyTEC brain toxicity dose levels and common prescription doses (e.g., 50.00% = 12Gy/24Gy). Power-law relationships of IDV and target volume (IDV = a*V^b) were generated from 200 targets (7.4%), then tested using hold-out data (2500 targets/92.6%), allowing a priori toxicity rate estimation via target parameters.

Results:

At least 98% of validation cohort IDV variance is explained by the training cohort models (R2≥0.979), allowing targets to be classified as either below or above HyTEC toxicity volume thresholds (IDV = 5cc, 10cc, and 20cc) with high accuracy (≥97.7%) and precision (≥98.9%). For the 50.0% IDV model (24Gy/1fx), it is predicted that target volumes/diameters of 1.08cc/1.27cm, 2.48cc/1.68cm, and 5.64cc/2.21cm correlate to 3.6% (IDV=5cc), 4.8% (IDV=10cc), and 8.6% (IDV=20cc) grade 1-3 brain toxicity rates, respectively. This analysis was repeated for six other common prescriptions/fractionations.

Conclusion(s):

HA models enabled accurate and precise prediction of the IDV resulting in toxicity according to HyTEC IDV thresholds. Relative IDVs were leveraged as opposed to prescribed dose, enabling all 2700 targets to be used for simulating each prescription level. Clinicians may now estimate brain toxicity a priori from target volume, surface area, largest axial dimension, or equivalent diameter for seven common SRS prescriptions (24Gy/1fx, 20Gy/1fx, 18Gy/1fx, 16Gy/1fx, 15Gy/1fx, 27Gy/3fx, and 30Gy/5fx) using an open source online calculator (https://uab-ro.github.io/Hypercalc/).