High Resolution Spectroscopic MRI and Scripting: Towards Automated Planning for a Multi-Center Clinical Trial

E Schreibmann, K Ramesh*, H Shu, H Shim

Department of Radiation Oncology and Winship Cancer Institute of Emory University, Atlanta, Georgia

High-Resolution Spectroscopic MRI

High-resolution, whole-brain spectroscopic MRI (sMRI) is capable of visualizing tumor diffusion in glioblastoma patients. With this approach, choline-to-N-acetyl aspartate (Cho/NAA) ratio is used to define a third, high-risk target volume that receives an escalated dose of 75 Gy (GTV3). To facilitate the safe use of Cho/NAA-guided radiation dose escalation and to simplify adoption of this targeting method to clinical practice, guidance from automation would be beneficial.

Purpose

To create an automated script incorporating our clinical experiences for sMRI-based dose escalation treatment plans.

Planning

Using scripting (ESAPI) we designed an Eclipse plug-in that incorporates our planning strategy.

What's different ?

An elevated 75 Gy GTV3 is targeted in the same plan with standard volumes of enhancing tumor and non-enhancing and/or edema defined on T1w-MPRAGE and T2-FLAIR, receiving 60 and 51 Gy respectively.

What's automated ?

Simulating our department's experience, the script performs:
- ✓ Creation of PTVs for all dosage levels
- ✓ Avoidance structures
- ✓ Treatment planning
- ✓ Constraints and weights (RapidPlan model)
- ✓ Optimization and dose calculations

What's the use ?

Convenient in presenting dosimetrists with an initial plan incorporating settings common to all patients. The plan can be further tweaked to satisfy specific trade-offs.

Conclusion

The script synthetizes in one package our department's trial-and-error experience with these cases to guide the acceptance of this new treatment paradigm into community practice.

Results

What's in the code ?

Margins and boolean operations between CTV and critical structures are handled by the script to create PTVs and avoidance structures. To predict the achievable dose to the critical structures, we employ a knowledge-based model to estimate the optimization constraints and corresponding weights. Settings for the optimization and dose calculation options are handled by the script as well and are established by feedback from our dosimetry group. The script generates an automated plan from the approved structures without any user interaction.
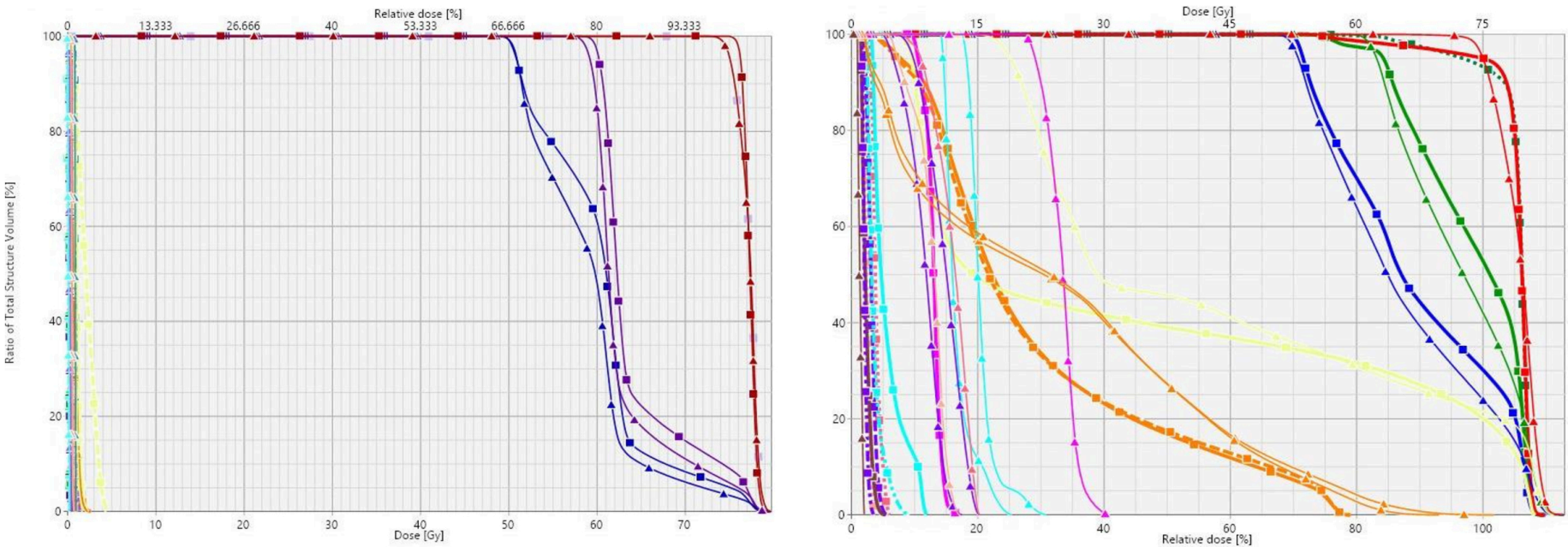
How are the numbers ?

Clinical plans had better dosimetric indices; however, minimal changes were needed to tweak the automated plans to a patient's specifics. Without any alteration of the automated plans for example:

Mean dose for the 3 targeting levels (GTV1, GTV2, and GTV3) was 59.9, 68.3 & 77.78 (automated) and 61.1, 69.6, & 77.11 Gy (clinical plans).

Minimum doses to the targets were 46.7, 56.2 & 70.0, (automated) and 48.2, 57.1 & 69.4 Gy (clinical)

OARs: mean maximum doses: (automated vs clinical)
Brainstem: 35.1 vs 31.7
Eyes: 8.1 vs 4.5
Hippocampus: 37.7 vs 37.5

Fig.1 Sample plan created by the script. The 3 target levels are GTV3 defined on spectroscopic MRI, GTV2 defined as bulk tumor on T1 contrast and GTV1 defined as edema on FLAIR.

Why use this script ?

The key to this script is the usage of settings determined optimal by our dosimetry team. While the planning approach for these cases is built on a workflow established for brain cases, specifics on the number of optimization rings, optimization margin for the PTV, as well as the arcs used for treatment and the optimization algorithms settings are customized for these types of novel treatments.

Fig. 2 Best and worst results are presented above. Figure shows DVH comparison of the clinical (squares) and automated (triangles) plans for a patient where the target was away from critical structures (left) and a plan where OAR proximities posed a challenge to the optimization algorithm (right).