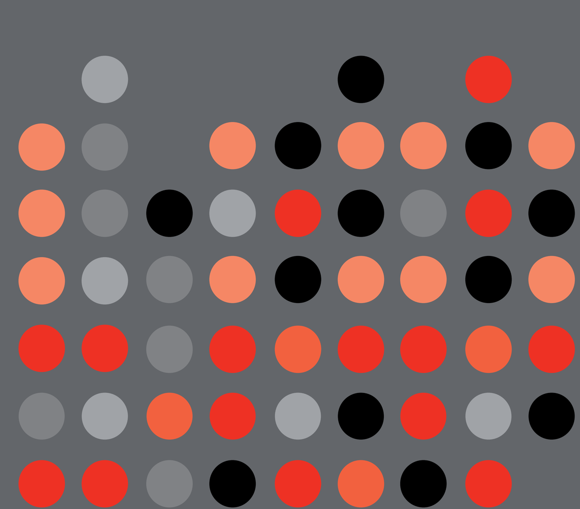

Feasibility of Automated VMAT Plan Creation for GBM Treatment using RapidPlan

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ABSTRACT

Glioblastoma Multiforme (GBM) is an aggressive cancer that can cause debilitating symptoms and requires prompt treatment. Radiation therapy is the standard care for management of this tumor. **RapidPlan (RP)** uses a library of previously planned cases to create a model to generate **dose volume histogram (DVH) estimations**, which are then converted to objectives for the automated creation of VMAT plans. The purpose of this study is to evaluate the feasibility of using RP for the automatic creation of VMAT plans for GBMs. The quality of plans using the RP model were compared with the quality of those generated manually and deemed clinically acceptable. The GBM plans used in this study were treated with a simultaneous integrated boost (SIB) prescription of 60 Gray (Gy) to the gross tumor and 50 Gy to the clinical target volume (CTV) in 30 fractions. The results of this study show RP produced better plans with statistically lower doses to OARs with a better CTV conformity index (CI).

Assessment of the mean values for the statistically significant parameters shows that RP generated better plans compared to the manual clinically acceptable plans. This supports the implementation of RP for treatment of GBM cases and allows for increased efficiency in the treatment planning of these complex cases that require immediate attention.

Keywords: *Glioblastoma Multiforme (GBM); Dose Volume Histogram (DVH) Estimations; RapidPlan (RP)*

INTRODUCTION

Radiation therapy is a treatment option that can be used to manage this brain tumor with a specified prescription and fractionation as set by the radiation oncologist. In comparison to surgery and chemotherapy, radiation therapy has proven to be an option of improved survival.[1] Radiation treatment planning of GBM can be achieved using 3D conformal radiation therapy (3DCRT), intensity-modulated radiation therapy (IMRT), or VMAT.

IMRT and VMAT techniques generate treatment plans with more dose conformality around the tumor and greater sparing of OARs. The sparing of healthy brain tissue needs to be maximized to avoid cognitive toxicity and structural brain changes.[2] Modulated plans are created by manually entering optimization objectives to achieve DVH goals. Manual VMAT planning for GBM is a time-consuming process due to the complexity of the treatment site and proximity of surrounding OARs.

New knowledge-based (KB) planning has been introduced in Eclipse as RapidPlan (RP) (Varian Medical Systems, Palo Alto, CA), which generates DVH estimations for a patient case using data gathered from previously treated plans.[3] This type of KB planning uses a traditional method to generate predications.[4] The DVH estimations are converted into objectives for the automated creation of a VMAT plan, which can significantly reduce the treatment planning time. Chatterjee et al. found that automated VMAT plans for GBM were created in 13 minutes versus four hours of manual planning.[5]

METHODS AND MATERIALS

Selection of 28 previously treated GBM plans, which were manually planned and proven clinically acceptable for treatment as defined by target coverage, OARs constraints, and monitor units (MUs), was done by reviewing the structures in the plans and quality of plans. These plans were used to configure a RP model specific for the treatment of GBM using Eclipse External Beam Planning version 15.6.

The first step was to create a DVH estimation model that includes the desired optimization objectives, description of anatomical region and prescription, normal tissue objective (NTO), and smoothing parameters. The list of OARs included in the model for GBM are the following: brainstem, brain_normal, optic nerves/chiasm, cochleas, lenses, pituitary gland, and spinal canal. The RP model was trained to analyze the anatomy and DVHs in the cases to create a mathematical DVH estimation model.

To validate the feasibility of the GBM RP model, a new selection of 10 previous clinically acceptable GBM cases was done, and copies of these plans were made. The copied plans were cleared of the dose and MLCs. The beam arrangement of the plans was kept. The plans were optimized using the RP model with the auto crop function. The RP model generated DVH estimations of the OARs for each plan. Plans were normalized to achieve the same GTV coverage of 60 Gy as the CP. A single iteration was performed for the RP copies. A comparative analysis was done to determine if RP created equivalent or better plans.

RESULTS

Table 1. Dosimetric parameters, mean results for RP and CP, and p-value

Dosimetric Parameter		Mean RP	Mean CP	P-value
Brainstem	V30 Gy<33%	11.01%	19.23%	0.019
Rt Optic Nerve	Dmax<54 Gy	19.71 Gy	24.73 Gy	0.024
Lt Lens	Dmax<5 Gy	3.03 Gy	3.65 Gy	0.020
Pituitary Gland	Mean<36 Gy Dmax<40 Gy	14.43 Gy 22.46 Gy	20.04 Gy 28.14 Gy	0.004 0.004
Spinal Canal	Dmax<45 Gy	1.93 Gy	2.14 Gy	0.018
Plan	Global dmax	109.9%	106.8%	0.005
CTV	CI	1.05	1.11	0.003

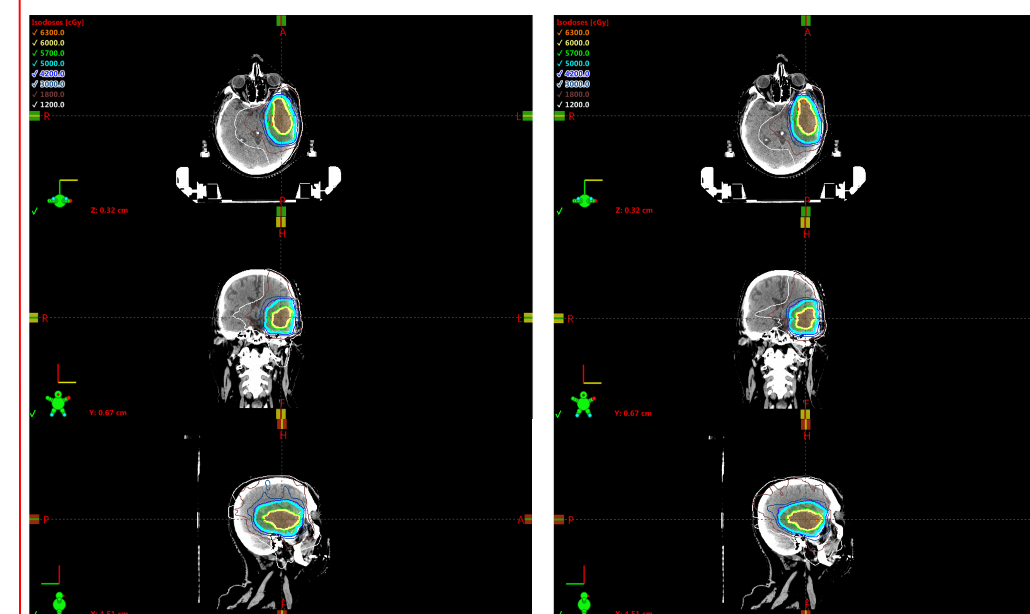

Figure 1. Image on left- axial, coronal, and sagittal views of dose distribution for CP. Image on right- axial, coronal, and sagittal views of dose distribution for RP.

DISCUSSION

Statistical significance in dosimetric parameters for RP vs the clinical plans (CP) was calculated using the Student's t-test with a p-value less than 0.05 used for statistical significance. The results of this study (Table 1) support the implementation of RP in the clinic for GBM treatment planning. RP can produce plans that meet the dosimetric parameters of a clinically acceptable GBM plan. Using RP reduces the number of iterations needed to achieve a clinically acceptable plan as demonstrated by statistical lower doses with better CI in the RP plans of this study. A limitation encountered in this study was the amount of GBM plans available for the creation of the RP model. Although the minimum requirement for a model is 20 plans, the quality of an RP model improves with more training plans.

CONCLUSION

Implementation of RP for treatment planning of GBM cases allows for increased efficiency. The main component in RP is its ability to create DVH estimations for plans based on previous cases. Additional gains in efficiency can be achieved using clinical protocols and auto-contouring software. Although RP can create better plans, medical dosimetrists still need to evaluate the plans and adjust based on the quality. Further research on the feasibility of RP for different treatment sites, such as head and neck, breast, and liver can be applied. The applicability of RP can also be studied to see its effect on the generation of DVH comparisons for insurance requirements. All in all, RP is a tool that can aid in delivering plans that require immediate attention such as GBM.

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