Intensity modulated therapy (IMRT) versus three dimensional conformal radiation therapy (3DCRT) for the treatment of high grade glioma: a dosimetric comparison

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OBJECTIVES

High-grade gliomas have a poor prognosis despite adjuvant treatment with radiation and chemotherapy. Due to their infiltrative nature, they require large margins for adequate radiation coverage. This may increase the risk for normal tissue toxicity and limit our ability to escalate radiation dose. IMRT is a technique proven to optimize target dose while enhancing normal tissue sparing. In this study, we performed a dosimetric comparison of IMRT versus 3DCRT techniques in patients treated for high-grade glioma.

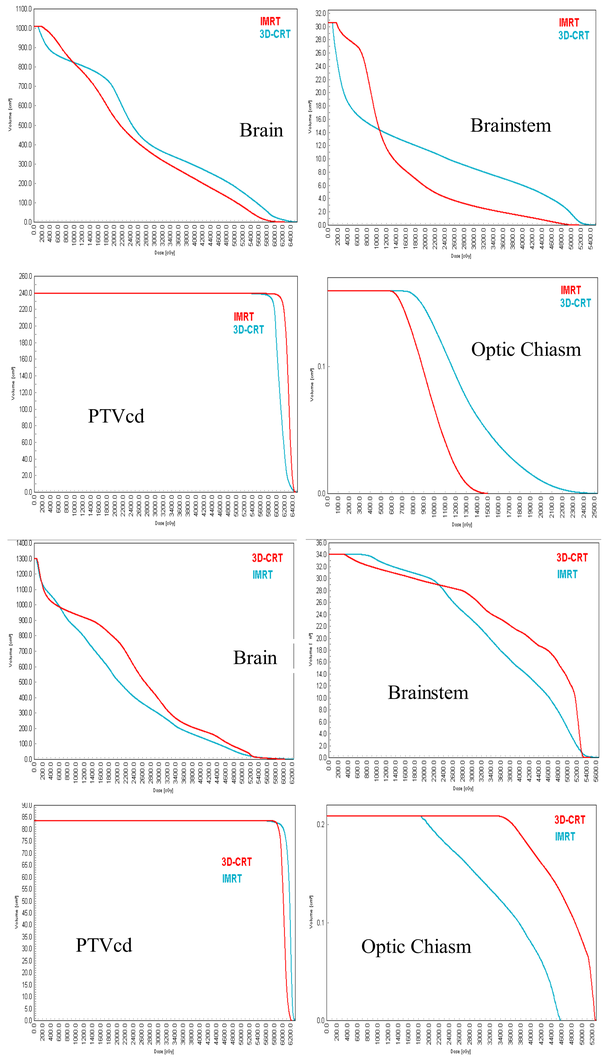

Figure 1. DVHs of two patients with high grade glioma planned with 3DCRT and IMRT techniques, the first with a right frontoparietal tumor (upper four DVHs) and the second with a left temporal lobe tumor (lower four DVHs).

RESUTS

IMRT resulted in superior target coverage and improved normal tissue sparing compared to 3DCRT as demonstrated by the DVHs in Figure 1. Specifically, minimum and mean planning target volume cone down (PTVcd) doses were 54.52 and 61.74 Gy for IMRT and 50.56 and 60.06 Gy for 3DCRT, respectively (Figure 2A). IMRT also lowered the percent PTVcd receiving below 59.4 Gy from 22.59% to 3.30% and the EUD from 60.76 Gy to 58.06 Gy (Figure 2B).

IMRT decreased the doses to brainstem, brain, left optic nerve and optic chiasm compared to 3DCRT, while no difference was found in the dosing of right optic nerve and cochlea. Specifically, IMRT reduced percent volumes of brain above 18, 24 and 45 Gy by 10%, 14% and 40% (Figure 3A) as well as the percent volume of brainstem receiving dose greater than 45 Gy by 31% (Figure 3B), respectively. The percent volume of optic chiasm receiving above 45 Gy was also reduced with IMRT by 30.40% (Figure 3C). Compared to 3DCRT, IMRT significantly increased TCP (Figure 4) and lowered NTCP for brain and brainstem (Figure 5).

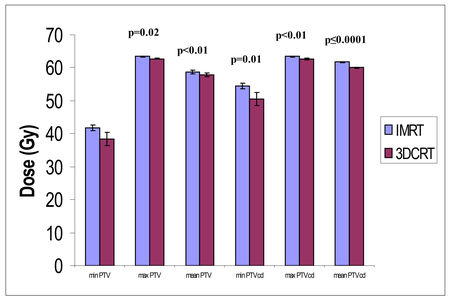

Figure 2A.

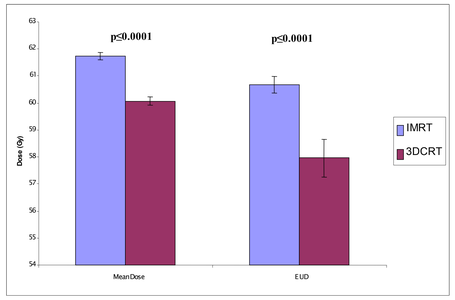

Figure 2B.

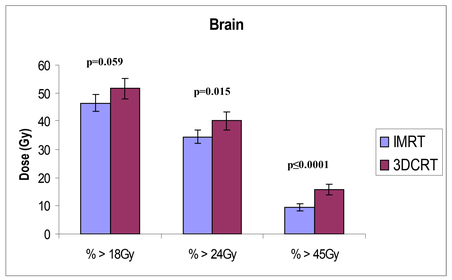

Figure 3A.

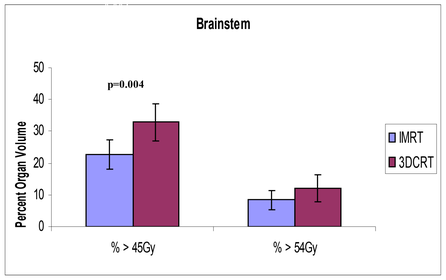

Figure 3B.

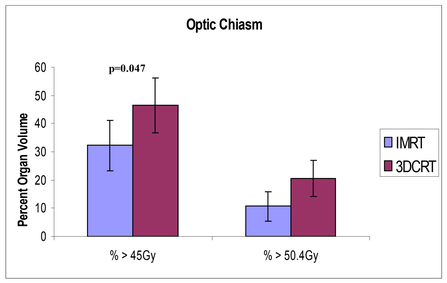

Figure 3C.

Figures 2A & B. Compared to 3DCRT, IMRT increased target minimum, maximum and mean doses of planning target volume (PTV) and PTV cone down (PTVcd) (A). IMRT also improved target equivalent uniform doses (EUD) (B).

Figure 3A, B & C. IMRT significantly decreased doses to normal brain (A), brainstem (B) and optic chiasm (C).

MATERIALS & METHODS

Twenty patients with high-grade glioma underwent computed tomography (CT) treatment planning in conjunction with magnetic resonance imaging (MRI) fusion to define target volumes and normal tissues. Prescription dose and normal tissue constraints were identical for both 3DCRT and IMRT plans. The prescribed dose was 59.4 Gy delivered at 1.8 Gy per fraction using 4-6 MV photons. Normal tissue dose constraints were 50-54 Gy for optic chiasm/nerves and 55-60 Gy for brainstem. Tumor and normal tissue dose volume histograms (DVHs) were generated and compared. Tumor control probability (TCP) and normal tissue complication probability (NTCP) were also calculated and compared.

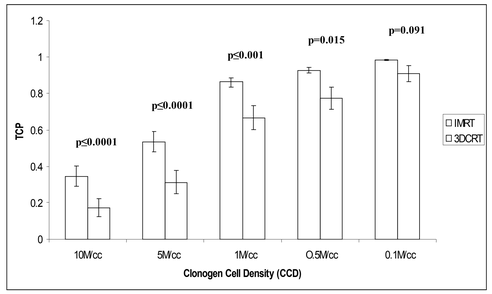

Figure 4. TCP was calculated for successively decreasing clonogen cell concentrations (CCD) of 10, 5, 1, 0.5 and 0.1 million per cubic centimeter (M/cc) of PTVcd volume. TCP was improved with IMRT.

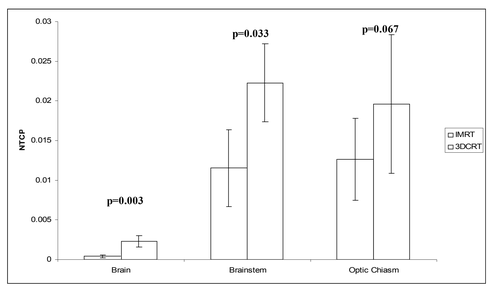

Figure 5. IMRT significantly decreased NTCP for normal brain, brainstem.

CONCLUSIONS

- **IMRT improved target coverage and tumor control probability in patients with high grade glioma.**
- **IMRT also improved sparing of normal brain, brainstem and optic chiasm.**
- **IMRT in combination with new more accurate tumor imaging tools and more effective systemic agents may be used to increase radiation doses while minimizing toxicity to improve outcomes in patients with high grade glioma.**