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A Dosimetric Analysis of Volumetric Arc Therapy for Whole Brain Hippocampal Sparing Technique Comparing Hyper-Flexion Versus Neutral Neck Position

Introduction

Brain metastases among cancer patients are a determining factor of poor prognosis occurring in up to a third of systemic malignancies. Brain metastases can most often affect the patient's morbidity, mortality, and quality of life.

Historically, brain metastases have been treated with 3D whole brain irradiation to achieve disease control, consisting of a right and left lateral field. This treatment option has led to patients having decreased neurocognitive function, ultimately decreasing their quality of life.

VMAT HA-WBRT (hippocampal avoidance-whole brain radiation therapy) vs 3D whole brain has been evaluated regarding organ at risk (OAR) dose reduction, particularly the hippocampal structure. However, the evaluation between hyper-flexion (30°) and neutral (0°) neck position in VMAT for metastases seems to be limited. This study will focus on hyper-flexion compared to neutral neck position, regarding treatment protocols and OAR constraints.

Methods

For each patient (sample size 9), a retrospective evaluation of their VMAT HA-WBRT plan was compared to a plan created from a diagnostic CT scan the patient had in neutral neck position. Clinical goals and constraints followed the NRG-CC001 trial. Contouring and target delineation followed RTOG 0933 guidelines.

Inclusion factors:

1. Patients had multi metastasis non-primary brain lesions.
2. Patients underwent HA-WBRT treatment to a dose of 30Gy in ten fractions using VMAT technique.
3. MRI used for planning fusion completed within 30 days of treatment.
4. Diagnostic CT was used for plan comparison within six months of simulation.
5. Patients had the ability to maintain a 30° hyper-flexion neck position for duration of simulation and treatment.

Exclusion factors:

1. Lesions in extreme close proximity (< 5mm) or penetrating the hippocampi structure.
2. The patient is unable to maintain the required 30° hyper-flexion for duration of time required for treatment setup and delivery.

Results

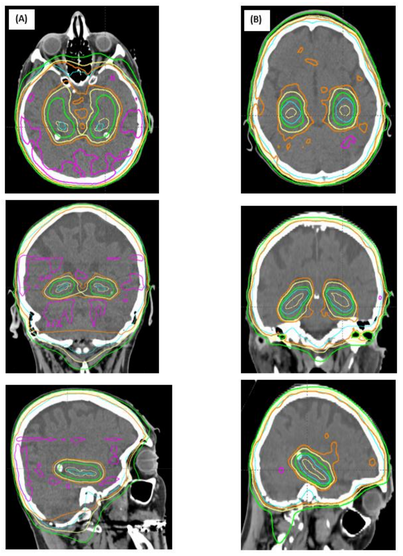

Figure 1. Dose distribution comparison of VMAT WBRT plan in neutral neck position (A) and the improved VMAT HA-WBRT plan with 30° neck flexion (B).

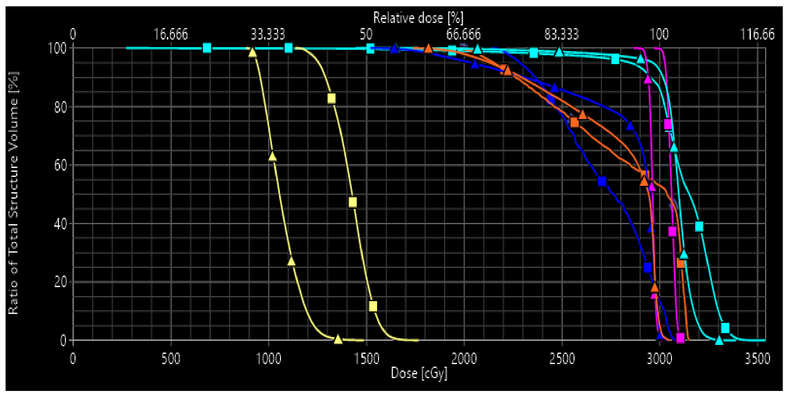

Figure 2. DVH plan comparison. Square indicating neutral neck positioning plan and triangle indicating 30° hyper-flexion plan. Structures represented: hippocampi (yellow), PTV (cyan), optic chiasm (purple), right optic nerve (orange), left optic nerve (blue).

Variable	Test Statistic	*p* value
Hot Spot (Point Max)	-22.5	0.0039
Total MU, MU ratio, Treatment Beam on Time	-21.1	0.0078
Hippocampi D100cGy	-20.5	0.0117
Right and Left Optic Nerves	-19.5	0.0195

Table 1. Data was determined to be significant or insignificant using the signed rank test (value produced: s-statistic). Each plan type comparison of the s-statistic then underwent a pairwise difference analysis to produce a p-value, indicating the significance level (*p-value* ≤ 0.05). The negative s-statistic value indicates the neutral neck position failed to prove better results compared to the 30° flexed.

Conclusion

Statistical evaluation was conducted using the signed rank test (s-statistic) and pairwise difference analysis (p-value). Constants of the research (brain volume (cc), PTV 95% coverage, CTV 90%) were proven to be statistically insignificant. Plan objectives that showed clinical significance of the HA-WBRT plan being the superior option included: plan hot spot, total monitor unit amount (MU), MU ratio, and treatment beam time on. Decrease of dose to OAR structures deemed superiorly significant for the HA-WBRT plan included: amount of hippocampi receiving 100% of dose, left and right optic nerve dose to 0.03cc of the structure. Data collected that failed to show a large enough difference between plan type, therefore insignificant, included: PTV CI, PTV Gradient, Hippocampal D0.035cc, Optic Chiasm D0.035cc.

Hippocampal avoidance while treating the whole brain in cases of brain metastasis is crucial to spare cognitive function for patients, therefore improving quality of life. This research shows that there is a clinically improved technique in planning HA-WBRT, when the patient's neck is hyper-flexed in a 30° position.

Limitations

The most challenging aspect of this research was the ability to create a neutral neck position (0°) plan for each patient that was statistically comparable in plan coverage.

References

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