Feasibility of hippocampal sparing radiation therapy for glioblastoma using helical Tomotherapy

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Purpose/Objective
With improvements in survival for good performance status patients with glioblastoma, some patients will survive to develop significant neurocognitive dysfunction. This retrospective planning study quantifies hippocampal radiation doses in twenty-five patients with glioblastoma receiving radical chemoradiotherapy, and evaluates the potential for dose reduction using helical Tomotherapy.

Material and Methods
We identified twenty-five glioblastoma patients treated with Helical IMRT (Tomotherapy Hi-ART, Accuray, Sunnyvale CA, USA) with concurrent and adjuvant temozolomide between October 2011 and December 2013 from our radiotherapy electronic database and conducted a retrospective analysis. Hippocampi (HC) were contoured in CT and MRI co-registered image data sets used for clinical radiotherapy planning and hippocampus planning risk volumes (HC-PRV) were created by adding five-millimetre isotropic margin which were checked by a neuro radiologist1 (fig 1). Clinical treatment dosimetry plans were overlaid to obtain dose statistics (fig 2). Four selected patients were planned for hippocampus avoidance radiotherapy (HA) without compromising tumour planning target volume (PTV) coverage using currently established hippocampus dose volume histogram (DVH) based constraints2 (figs 3 & 4).

Results
Mean HC-PRV maximum, minimum and mean radiation doses were 54.7, 24.15 and 38.62 Gy respectively (table 1). HC-PRV V7.3, V14.9 and V20 (volumes receiving 7.3, 19.9 and 20 Gy respectively) were 99.95%, 96.41% and 95.72% and hippocampus V3 was 100% (table 2). In seventeen patients ipsilateral hippocampi were within PTVs and in seven patients both hippocampi were outside PTVs with only minimal overlapping volumes but DVH based dose constraints were not achieved (tables 3 & 4).

With hippocampus avoidance radiotherapy planning, in four patients HC-PRV minimum doses and in three patients mean HC-PRV doses were reduced and significant reductions in DVH based dose constraints were achieved in three patients when compared to clinical treatment plans (table 5).

Conclusion
Our analysis showed hippocampus PRVs received significant radiation doses and currently established hippocampus DVH parameters were not achieved during cranial radiotherapy for glioblastoma using Helical IMRT without hippocampus avoidance planning. Our planning study demonstrated significant dose reductions were possible with hippocampus avoidance radiotherapy planning in selected patients. More clinically correlated DVH objectives for hippocampus are required for better optimisation for hippocampus avoidance cranial radiotherapy in glioblastoma to be considered for all patients.

Key words: glioblastoma, hippocampus avoidance radiotherapy, neurocognitive function

2Preservation of Memory With Conformal Avoidance of the Hippocampal Neural Stem-Cell Compartment During Whole-Brain Radiotherapy for Brain Metastases (RTSG 0933); A Phase II Multi-Institutional Trial, JCO, Vol. 32, No. 34 3810-16, 2014