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Abstract

Hippocampal-Sparing and Target Volume Coverage in Treating 3-10 Brain Metastases: A Comparison of 192-Source Cobalt, Single-Isocenter VMAT, Non-Isocentric Robotic Arm-Mounted LINAC, and Helical TomoTherapy Stereotactic Radiosurgery

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Abstract

Objectives: To evaluate hippocampal doses and target volume coverage with and without hippocampal-sparing when treating multiple brain metastases using various stereotactic radiosurgery (SRS) platforms.

Methods: We selected 10 consecutive patients with a total of 14 treatments who had been treated in our department for 3-10 brain metastases and added hippocampal avoidance contours to the planning volumes. All 14 treatments were replanned with 4 separate vendor-provided, platform specific software, e.g. cobalt (platform A), single-isocentric VMAT delivered with 4 non-coplanar arcs (platform B), non-isocentric LINAC (platform C), and tomotherapy (platform D). Initial treatment planning was performed with a PTV coverage goal of V100>95% without hippocampal avoidance. If the maximum hippocamal point dose (Dmax) was <6.6 Gy in a single fraction and <40% of the hippocampi received =4.5 Gy, no second plan was performed. If either constraint wasn't met, replanning was performed with these constraints.

Results: There was a median of 6 metastases per plan, with an average single tumor volume of 1.34 cc and total tumor volume of 7.32 mL per plan. The median hippocampal Dmax (in Gy) without sparing averaged 1.65, 9.81, 4.38, and 5.46, respectively (p<0.0001). Of 14 plans, three plans required replanning in platforms A and C, while 13 plans in platform B and eight plans in platform D required replanning. The hippocampal constraints were not achievable in one plan on any platform when the tumor abutted the hippocampus. The mean volume of brain receiving 12 Gy (in mL), which has been associated with symptomatic radionecrosis, was 23.57 with platform A, 76.77 with platform B, 40.86 with platform C, and 104.06 with platform D (p = 0.01). There was also a significant difference in the volume of brain receiving 8 Gy and 4 Gy across treatment platforms (p<0.001 and p<0.0001, respectively), with platforms A and C treating less low-dose volumes of normal brain. The overall average conformity indices for all plans ranged from 0.36 to 0.52 (p=0.07). There was a significant difference in treatment time between platforms, with an average "beam on" time (in minutes) of 155 (A), 9.4, 100.4 (C), and 49.3 (D).

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Conclusions: Cognitive decline is a significant concern in patients receiving whole brain radiation; however, neurocognitive deficits are also found after SRS alone for multiple brain metastases. We found that despite the conformity of SRS, the hippocampi can receive a considerable dose with standard planning. However, if the hippocampi are outlined as organs at risk, sparing of these structures is feasible in nearly all situations and should be considered in all patients undergoing SRS for brain metastases.