Intensity modulated proton beam therapy

Proton therapy (PRT) is an advanced radiotherapy (RT) modality with a unique dose-deposition pattern that allows for treatment of a target volume with reduced scatter dose delivered to normal tissues compared with conventional photon RT and is now increasingly utilized in children with the hope of mitigating radiation-induced late effects. A article reviews the current literature evaluating the use of PRT in benign and low-grade pediatric central nervous system tumors such as low-grade glioma, craniopharyngioma, and ependymoma. Multiple dosimetric studies support the use of PRT by demonstrating the ability of PRT to better spare critical structures important for cognitive development, endocrine function, and hearing preservation and to reduce the total body dose associated with second malignancy risk. Early clinical data demonstrate that PRT is well tolerated with rates of local tumor control comparable to conventional photon RT series, and long-term clinical data are awaited [1].

Intensity modulated proton beam therapy appears equivalent in terms of local control, but may be better at sparing normal tissue [2].

Proton radiotherapy (PRT) reduces the volume of normal tissue receiving radiation dose, which may lead to better neurocognitive outcomes.

The outcomes of intensity-modulated proton craniospinal irradiation (ipCSI) are unclear.

Hashimoto et al., evaluated the clinical benefit of our newly developed ipCSI system that incorporates two gantry-mounted orthogonal online X-ray imagers with a robotic six-degrees-of-freedom patient table. Nine patients (7-19 years old) were treated with ipCSI. The prescribed dose for CSI ranged from 23.4 to 36.0 Gy (relative biological effectiveness) in 13-20 fractions. Four adolescent and young adult (AYA) patients (15 years or older) were treated with vertebral-body-sparing ipCSI (VBSipCSI). Myelosuppression following VBSipCSI was compared with that of eight AYA patients treated with photon CSI at the same institution previously. The mean homogeneity index (HI) in the nine patients was 0.056 (95% confidence interval: 0.044-0.068). The mean time from the start to the end of all beam delivery was 37 min 39 s ± 2 min 24 s (minimum to maximum: 22 min 49 s - 42 min 51 s). The nadir white blood cell, hemoglobin, and platelet levels during the 4 weeks following the end of the CSI were significantly higher in the VBSipCSI group than in the photon CSI group (P = 0.0071, 0.0453, 0.0024, respectively). The levels at 4 weeks after the end of CSI were significantly higher in the VBSipCSI group than in the photon CSI group (P = 0.0023, 0.0414, 0.0061). Image-guided ipCSI was deliverable in a reasonable time with sufficient HI. Using VBSipCSI, AYA patients experienced a lower incidence of serious acute hematological toxicity than AYA patients treated with photon CSI [3].

Kahalley et al., examined change in neurocognitive scores over time in pediatric brain tumor patients treated with proton craniospinal irradiation (CSI), proton focal RT, or surgery only.

Patients received annual neurocognitive evaluations for up to 6 years. We examined Full Scale IQ (FSIQ), Verbal Comprehension (VCI), Perceptual Reasoning (PRI), Working Memory (WMI), and Processing Speed Index (PSI) scores. General linear mixed models examined change in scores over time by treatment group, adjusting for significant covariates.

Scores from 93 patients treated between 2012-2017 (22 proton CSI, 31 proton focal, and 40 surgery only) were examined. Treatment groups were similar on gender (51.6% male), age at treatment (median=9.7 years), and length of follow-up (median=2.9 years). The surgery only group had proportionately more gliomas (p<0.001), and the proton CSI group had more infratentorial tumors (p=0.001) and higher total RT dose (p=0.004). The proton focal and surgery only groups exhibited stable neurocognitive scores over time across all indexes (all p>0.05). In the proton CSI group, WMI, PSI, and FSIQ scores declined significantly (p=0.036, 0.004, and 0.017, respectively), while VCI and PRI scores were stable (all p>0.05).

Focal PRT was associated with stable neurocognitive functioning into survivorship. Outcomes were similar whether patients received focal PRT or no radiotherapy, even in neurocognitive domains known to be particularly radiosensitive. Proton CSI emerged as a neurocognitive risk factor, consistent with photon outcomes research [4].

1)
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