Comparison of RapidArc Volumetric Modulated Arc Therapy, Helical Tomotherapy, and 3D Conformal Radiotherapy for Pediatric Craniospinal Irradiation

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Purpose/Objective(s): To compare dosimetric parameters, integral body dose, and treatment times of volumetric modulated arc therapy (VMAT), helical tomotherapy (HT), and three-dimensional conformal radiotherapy (3D-CRT) for craniospinal irradiation (CSI) of pediatric patients with medulloblastoma.

Materials/Methods: Three children who had previously undergone CT simulation in the supine position for CSI and treated using 3D-CRT were re-planned using HT and VMAT. Tomotherapy HiArt was used to generate HT plans using a single helical arc, which eliminates the need for field junctioning. VMAT planning was completed with Varian RapidArc using two arcs each for the brain and spine. Planning objectives for HT and VMAT were for 95% of the PTV (entire craniospinal axis with margin) to receive 23.4 Gy in 13 fractions while minimizing dose to surrounding normal structures. Dose-volume histogram data, integral body doses, and beam-on times were compared using matched-pair analysis.

Results: Planning goals were met for all plans. The maximum PTV dose was significantly higher with VMAT (26.2 ± 0.2 Gy) compared to HT (25.4 ± 0.3 Gy; p = 0.025) but similar to 3D-CRT (27.8 ± 2.1 Gy; p = 0.248). For surrounding normal tissues, VMAT resulted in significantly reduced V(10 Gy) of the skin, lungs, esophagus, heart, liver, kidneys, and peritoneal cavity, V(15 Gy) of the skin, eyes, lungs, esophagus, kidneys, peritoneal cavity, and vertebrae, and V(20 Gy) of the eyes and lenses compared to 3D-CRT (all p < 0.05). Compared to HT, VMAT resulted in significantly reduced V(10 Gy) of the skin, lenses, thyroid, and peritoneal cavity, and V(15 Gy) and V(20 Gy) of the skin and vertebrae, but higher V(10 Gy) of the lungs and esophagus (all p < 0.05). Mean integral dose for the body contour was significantly reduced with VMAT (108.2 ± 15.3 J) compared to HT (117.7 ± 16.7 J; p = 0.031), and with a trend towards reduction compared to 3D-CRT (118.7 ± 16.8 J; p = 0.064). Mean beam-on time per fraction for VMAT of 240 ± 0 sec was significantly lower than for HT (437 ± 43 sec; p = 0.012) but significantly higher than for 3D-CRT (60 ± 3 sec; p < 0.001).

Conclusions: In the planning of pediatric CSI, VMAT results in significantly reduced integral body dose and beam-on time compared to helical tomotherapy. VMAT planning also achieved reduced doses to many surrounding normal tissues, but higher doses to the lungs and esophagus and worsened PTV dose homogeneity compared to helical tomotherapy. When compared to 3D-CRT, VMAT resulted in significantly lower surrounding normal tissues but with higher beam-on times. From these results, we have demonstrated potential advantages of RapidArc VMAT for pediatric craniospinal irradiation.

Author Disclosure: S. Patel, None; H. Warkentin, None; K. Powell, None; A. Syme, None; B. Warkentin, None; G. Fallone, None.