Craniospinal irradiation

Indications

Craniospinal irradiation is used for patients who have or are at risk for, disseminated disease throughout the CNS that is not sufficiently responsive to chemotherapy (typically methotrexate). This includes:

Embryonal CNS malignancies (medulloblastoma, primitive neuroectodermal tumor, atypical teratoid/rhabdoid tumor) Intracranial germ cell tumor with evidence of distant CNS metastases Ependymoma with evidence of distant CNS metastases or CSF involvement

Craniospinal irradiation for medulloblastoma treatment

Technique

The issues with craniospinal irradiation are:

Junctioning of the cranial fields (opposed laterals) with the spine field (posterior unopposed field) Junctioning of the spine fields when the spinal meninges are too long to treat as a single field. It is one of the most complex planning techniques in radiation oncology. Radiation should start within ten days of surgery for the best result.

Pre-Simulation

These patients are often young and have significant long-term risks of treatment.

Informed consent should be obtained, with parents giving consent if the child is under 16. Fertility should be discussed with the patient. Males after puberty should consider cryopreservation of sperm. Females should consider the possibility of cryopreservation of embryos (if in a relationship), oocytes, or ovarian tissue. Simulation

Young children may require anesthesia for simulation and subsequent treatments. Patients are simulated prone, with vacuum bags under the abdomen and knee support. The head is supported on a headrest with jaw and forehead support to allow for respiration, the head is extended comfortably to prevent the spine field from exiting through the jaw. The head is then immobilised in a thermoplastic mask. It is desirable to obtain as straight a spine as comfortable to standardise the distance of the spinal cord (or column in children under 18) from the beam source. The patient should receive tattoos along the spine to ensure set up accuracy.

Planning

Fusion of the pre-operative MRI and the planning CT should be performed to aid field and volume placement. Treatment is with a two-phase technique; children under 15 are treated with 23.4 Gy to the craniospinal axis and a 30.6 Gy boost to the primary tumor with a 2 cm expansion. Older children

and adults receive 36 Gy to the craniospinal axis with an 18 Gy boost to the tumor bed.

Spinal Fields

The superior spinal field is placed first. It should be aligned so that central beam axis is perpendicular to the vertebral column, and the field should be as large as possible. The superior beam edge should exit below the level of the jaw to prevent oral early and late effects. The lateral edges should be 1 cm to the pedicles of the spine to ensure adequate dose within the meninges. The inferior extent of the field should include the filum terminal, as visible on the MRI, or alternatively be junctioned with an inferior spinal field. The inferior spinal field should be matched at the level of the midcord, and the junction feathered by 1 cm every day to reduce the impact of hot and cold spots.

Cranial Fields

The cranial fields are placed next. These fields should have the collimator rotated to match the divergence of the posterior spine field. The isocentre will be midline and anterior to the equator of the orbit to prevent divergence into the contralateral eye. There are two significant issues with the cranial fields:

Shielding: The fields must cover the cribriform plate (5 mm margin) and temporal fossa (1 cm margin) and these should be verified with image guidance daily with 0 cm tolerance. Junction: The junction with the spine field can be performed through several means. A single match rotates the collimator only, with hot and cold spots located at the junction. This technique necessitates a feathered junction to blur out this region. A double match rotates the collimator and the couch to align the divergence of the lateral beams with the divergence of the spinal field. Due to inaccuracies in patient set up, a feathered junction is still required and the benefit of this technique over the single match technique is not entirely clear, especially given the increased complexities with couch movements. Phase 2

Phase two involves a boost to the primary tumour bed and any metastatic sites to 54 Gy. The pre-operative extent of the tumour is contoured and a CTV of 2 cm is added. An additional 0.5 cm setup margin to PTV follows. This volume is then treated with a 3D conformal technique.

Organs at Risk

These include:

Optic Apparatus Lens < 3 Gy Retina < 45 Gy Optic Nerve and Chiasm < 50.4 Gy CNS structures Brainstem < 54 Gy Max Cochlea < 30 Gy Max Salivary glands < 26 Gy Mean Viscera Lung mean dose < 20 Gy Liver mean dose < 30 Gy Kidney lung dose < 18 Gy Newer Methods

Proton Treatment

Protons have the distinct advantage of minimal dose deposition beyond the Bragg peak. This allows dose to be limited to the anterior aspect of the vertebral bodies with minimal dose extending into the

more anterior structures. This should, ideally, limit late complications of treatment but formal randomized studies are lacking and the treatment itself is not available in Australia and is significantly more expensive.

Tomotherapy

Tomotherapy treats patients with a rotating fan beam. It avoids the need for junctioning in the spinal cord, but does increase dose to parts of the body that would normally be avoided with a single posterior beam. Whether it offers a significant advantage over conventional planning is controversial.