Adult Medulloblastoma

18

C. Jane Cho and Lia M. Halasz

Contents

18.1 General Principles of Simulation and Target Delineation

- See Tables 18.1, 18.2, 18.3 and 18.4.
- Staging with spine MRI and cerebrospinal fluid sampling is essential for determining whether a patient is average-risk or high-risk.
  - Average risk: ≥3 years of age, M0, ≤1.5 cm^2 of residual disease postop and favorable histology.
- Obtain thin slice brain MRI with T1 pre- and post-gadolinium for target delineation. Medulloblastoma heterogeneously enhance on T1 with contrast and can also be visualized on DWI sequence. Fuse both the preoperative and postoperative (within 72 h) MRIs to help delineate target volume.
- Preoperative MRI of the whole spinal canal is ideal. Include both T1 pre- and post-gadolinium to define drop metastases if present and T2 to determine the extent of the cerebrospinal fluid (CSF) space and thecal sac. Postoperative spinal MRI should be obtained at 10–14 days postop to avoid a false-positive result.
  - Spinal MRI should include the whole sacrum.

C. J. Cho
MultiCare Radiation Oncology, Tacoma, WA, USA

L. M. Halasz (✉)
Department of Radiation Oncology, University of Washington, Seattle, WA, USA
e-mail: lhalasz@uw.edu

L. M. Halasz et al. (eds.), *Intracranial and Spinal Radiotherapy*, Practical Guides in Radiation Oncology, https://doi.org/10.1007/978-3-030-64508-3_18

Table 18.1 Suggested target volumes for craniospinal irradiation

CTV	Entire CSF space at risk for disease dissemination. Cranial contents including cribriform plate, superior orbital fissure, Meckel's cave, foramen rotundum, foramen ovale, internal auditory meatus, jugular foramen, and hypoglossal canal. Controversy regarding whether to include whole or posterior portion of optic nerves. Spinal canal including intervertebral foramina. Sacral nerve roots do not need to be included. Visualize inferior border of the thecal sac on MRI scan (Figs. 18.1 and 18.2) [1]
PTV	CTV + 0.5–0.7 cm depending on the comfort of patient positioning, mask fit, and image guidance technique (AP/lateral imaging or cone beam CT)

Table 18.2 Suggested target volumes for tumor bed boost approach

Target volumes	Definition and description
GTV	Residual tumor and resection cavity on postoperative T2/FLAIR and T1 post-gadolinium images. Preoperative MRIs are helpful for determining residual disease and resection cavity
CTV	GTV + 1.5 cm. This can be edited around anatomic boundaries such as the bone, tentorium, dura, and brainstem
PTV	CTV + 0.3–0.5 cm depending on comfort of patient positioning, mask fit, and image guidance technique (AP/lateral imaging or cone beam CT)

Table 18.3 Suggested target volumes for posterior fossa boost approach

Target volumes	Definition and description
CTV	• Entire posterior fossa including the brainstem. Use sagittal and coronal MRI to assist in identification of the tentorium. Superior: tentorium cerebelli. Anterior: anterior border of the cerebellar folia, brainstem, midbrain • Lateral and posterior: bony walls of the occiput and temporal bones • Inferior: C1–C2 junction
PTV	CTV + 0.3–0.5 cm depending on the comfort of patient positioning, mask fit, and image guidance technique (AP/lateral imaging or cone beam CT)

Table 18.4 Craniospinal irradiation treatment techniques

3D conformal photons	
Brain field	Often treated with lateral opposed fields with collimator rotation and couch kick to match the spine field divergence and gantry tilt to decrease divergence to the lenses. Borders include flash for superior and posterior borders, 0.5 cm below the cribriform plate, and 1 cm margin anteriorly to vertebral bodies and inferiorly to the middle cranial fossa
Spine field	Superior, C4–C7; lateral, 1 cm margin from the vertebral bodies and fully covered sacral foramina; inferior, 1–2 cm margin inferior to the end of thecal sac which is determined with the T2 sequence of MRI of the spine but is typically located near S2 Feathering can be performed every five fractions or daily with at least three different junctions [2]. A gap of 0–5 mm has been used and the practice is institution-dependent
Protons	
Brain field	Often treated with single PA field, two posterior oblique fields, or opposed lateral fields
Spine field	Posterior fields matched with either feathering junction (uniform scanning) or gradient matching fields (pencil beam scanning) [3]

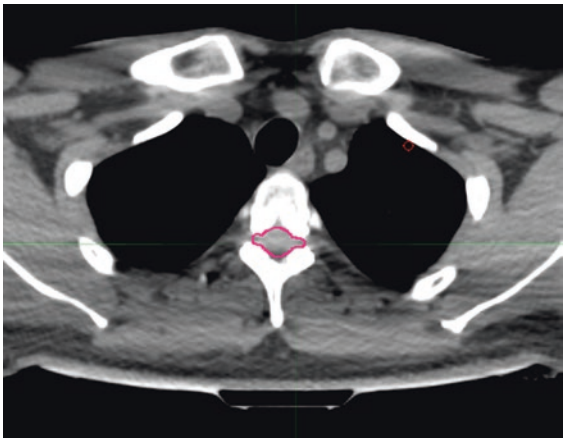

Fig. 18.1 Contours for spine CTV (pink) should include the entire arachnoid space with nerve roots

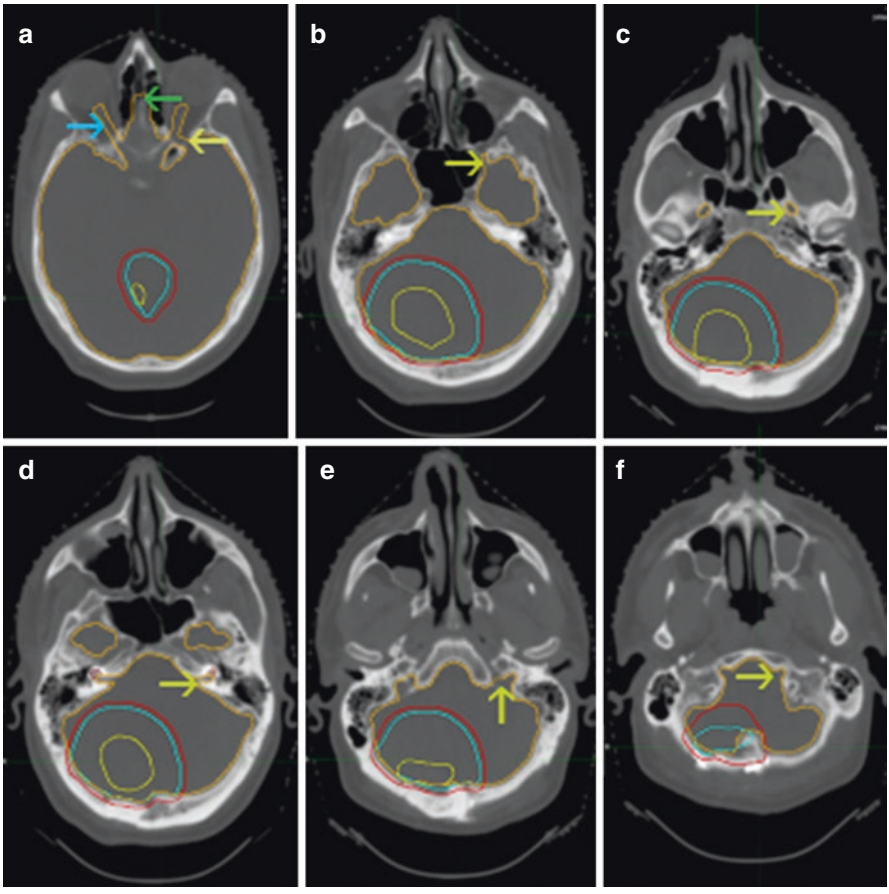

Fig. 18.2 Contours for brain CTV (orange) should include (**a**) superior orbital fissure (yellow arrow) and cribriform plate (green arrow) and consider optic nerve sheaths (blue arrow) (**b**) foramen rotundum, (**c**) foramen ovale, (**d**) internal auditory meatus, (**e**) jugular foramen, and (**f**) hypoglossal canal. Involved field boost contours for average-risk medulloblastoma include GTV (yellow), CTV (teal), and PTV (red)

- If the patient has contraindications to MRI, can use CT with and without contrast.
- CT simulation with a thermoplastic mask and body immobilization for craniospinal irradiation (CSI) with 1–2.5 mm slice thickness:
  - Treatment may be delivered either supine (more comfortable for patient and stable positioning) or prone (advantage is to visualize the spinal junction match lines on the skin, if using traditional CSI technique, but uncomfortable for patient).
  - Hyperextension of the neck can optimally spare the esophagus and larynx.

18.2 Dose Prescriptions

- Treatment of the brain and spinal canal after maximal safe resection
  - Average risk: CSI 23.4–36 Gy and boost to 54–55.8 Gy to tumor bed with margin depending on chemotherapy used. Only consider deescalating from 36 Gy if utilizing Packer regimen for chemotherapy.
  - High risk: CSI 36 Gy in 20 fractions and boost to the posterior fossa or tumor bed with margin to 54–55.8 Gy. Note: Tumor bed boost approach is being increasingly utilized for high-risk medulloblastoma, but has not been established by clinical trials.
- Boost to metastatic lesion
  - Intracranial mets, focal spinal mets below the cord: 50.4 Gy
  - Focal spinal mets above the cord terminus: 45 Gy
  - Diffuse spinal mets: 39.6 Gy

18.3 Treatment Planning Techniques

- *See* Table 18.4 and Figs. 18.3, 18.4 and 18.5.
- 3D CRT, IMRT, VMAT, or proton therapy may be used with the goal of sparing the bone marrow, heart, lungs, kidneys, and bowel for the CSI portion and the supratentorial brain, hypothalamus, pituitary, optic apparatus, and cochleae for the boost portion.
- Treatment planning aims to cover 95% of the PTV volume by 95% of the prescribed dose for photon plans and 100% of the CTV volume by 100% of the prescribed dose for proton plans.
- OARs for 3DCRT or IMRT plans: supratentorial brain, cochlea, hypothalamus/pituitary, eyes, optic nerves, optic chiasm, cervical spinal cord (foramen magnum to top of C2), and skin (Table 18.5).

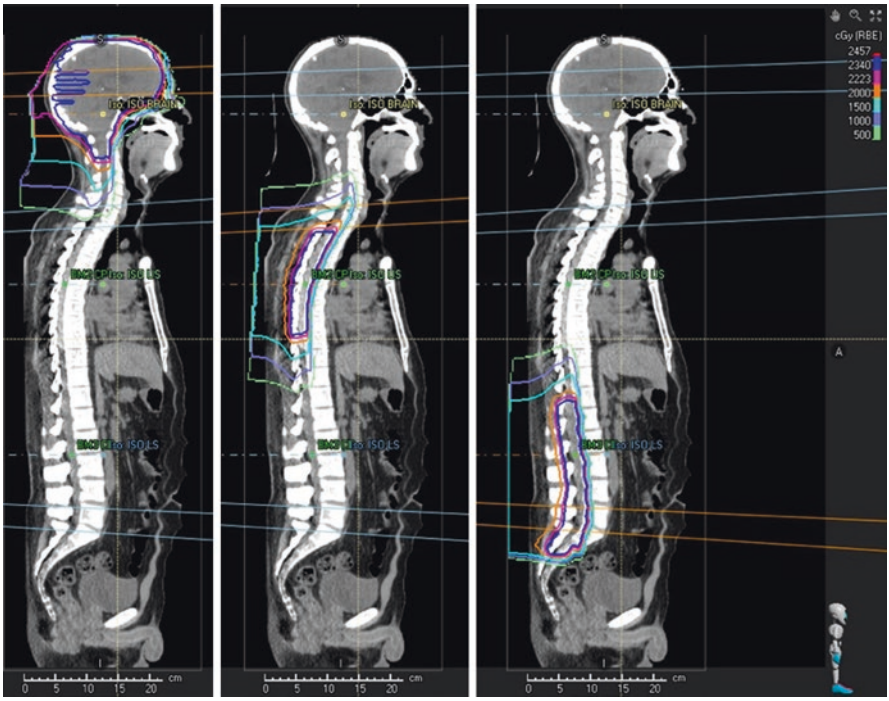

Fig. 18.3 Sample proton plan for the above patient with medulloblastoma utilizing three PA beams that are matched and feathered by overlapping gradients at each junction

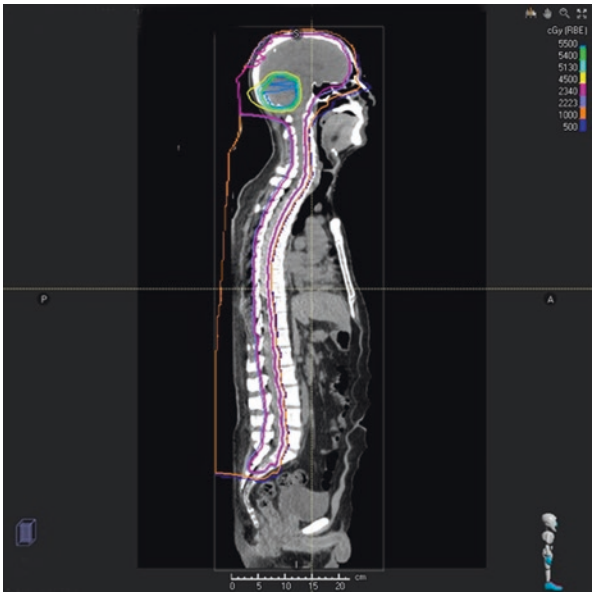

Fig. 18.4 Composite proton plan with gradient matching

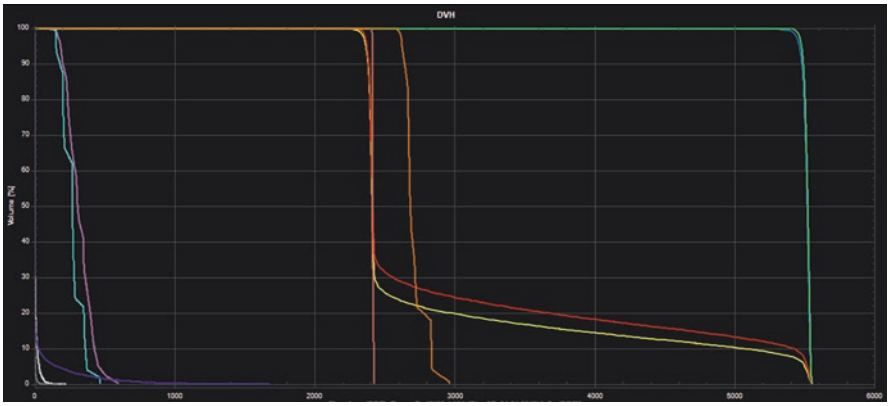

Fig. 18.5 Sample dose-volume histogram for the above patient with medulloblastoma. CTV boost, green; PTV boost, dark blue; CTV craniospinal, red; PTV craniospinal, yellow; cochleae, orang; lenses, teal and lilac; lungs, dark purple; esophagus, white; kidneys, gray

Table 18.5 Recommended normal tissue constraints for 1.8 Gy/day fractionation schemes

Organs at risk	Suggested dose constraints
Spinal cord between C1 and C2 (foramen magnum to top of C2)	V45 Gy <50% [4]
Optic nerves and chiasm	D_{max} <55 Gy
Cochleae	Mean 35 Gy if possible [5]
Brainstem	Brainstem at 0.1 cm^3 <56.6 Gy (acceptable: D0.1 cc ≥56.6 but <58) Brainstem at 50% volume <52.4 Gy (acceptable: D50 ≥52.4 but <54) Brainstem at 10% volume <55.4 Gy (acceptable: D10 ≥55.4 but <56) [6]

Table 18.6 Side effects

Acute	Hair loss, fatigue, headaches, nausea, diarrhea, fatigue, alopecia, hearing changes, myelosuppression, and cerebral edema causing neurological symptoms
Long-term	Neurocognitive decline, decreased growth, hypopituitarism, hypothyroidism, hearing loss
Uncommon or rare risks	Lhermitte's syndrome, gonadal dysfunction, brain or brainstem injury, secondary malignancies

18.4 Side Effects

- See Table 18.6.
- Recommend weekly patient weights and CBC with differential during treatment. Consider daily premedication with ondansetron.

References

1. Ajithkumar T et al (2018) SIOPE—brain tumor group consensus guideline on craniospinal target volume delineation for high-precision radiotherapy. Radiother Oncol 128(2):192–197
2. Cao F, Ramaseshan R, Corns R, Harrop S, Nuraney N, Steiner P, Aldridge S, Liu M, Carolan H, Agranovich A, Karvat A (2012) A three-isocenter jagged-junction IMRT approach for craniospinal irradiation without beam edge matching for field junctions. Int J Radiat Oncol Biol Phys 84(3):648–654. Epub 2012 Mar 19. https://doi.org/10.1016/j.ijrobp.2012.01.010
3. Lin H, Ding X, Kirk M, Liu H, Zhai H, Hill-Kayser CE, Lustig RA, Tochner Z, Both S, McDonough J (2014) Supine craniospinal irradiation using a proton pencil beam scanning technique without match line changes for field junctions. Int J Radiat Oncol Biol Phys 90(1):71–78
4. https://www.clinicaltrials.gov/ct2/show/NCT00085735
5. Paulino AC, Lobo M, Teh BS, Okcu MF, South M, Butler EB, Su J, Chintagumpala M (2010) Ototoxicity after intensity-modulated radiation therapy and cisplatin-based chemotherapy in children with medulloblastoma. Int J Radiat Oncol Biol Phys 78(5):1445–1450
6. Haas-Kogan D et al (2013) National Cancer Institute Workshop on proton therapy for children: considerations regarding brainstem injury. IJROBP 101(1):153–168

Further Reading

ACN atlas. https://www.qarc.org/cog/ACNS0331Atlas.pdf

Brown AP et al (2013) Proton beam craniospinal irradiation reduces acute toxicity for adults with medulloblastoma. Int J Radiat Oncol Biol Phys 86(2):277–284

Franceschi E, Hofer S, Brandes AA et al (2019) EANO-EURACAN clinical practice guideline for diagnosis, treatment, and follow-up of post-pubertal and adult patients with medulloblastoma. Lancet Oncol 20(12):e715–e728

Merchant TE et al (2008) Multi-institution prospective trial of reduced-dose craniospinal irradiation (23.4 Gy) followed by conformal posterior fossa (36 Gy) and primary site irradiation (55.8 Gy) and dose-intensive chemotherapy for average-risk medulloblastoma. IJROBP 70(3):782–787

Michalski JM et al (2016) Results of COG ACNS0331: a phase III trial of involved-field radiotherapy (IFRT) and low dose craniospinal irradiation (LD-CSI) with chemotherapy in average-risk medulloblastoma: a report from the Children's Oncology Group. IJROBP 96(5):937–938