Intracranial Germ Cell Tumors

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Contents

19.1 General Principles of Simulation and Target Delineation (Table 19.1, Figs. 19.1 and 19.2)

- Germinomas make up about 60–70% of all germ cell tumors.
- Non-germinomatous germ cell tumors (NGGCTs) are often mixed tumors that can be composed of yolk sac tumor, embryonal carcinoma, and/or choriocarcinoma. Can include germinoma or teratoma or both.
- Usually occur in the pineal or suprasellar region. Always check both regions for multifocal involvement.
- Staging with spine MRI before surgery or 10–14 days after surgery is essential for determining whether a patient has disseminated disease.
- Lumbar cerebrospinal fluid (CSF) sampling after acute hydrocephalus is addressed is essential for determining whether a patient has disseminated disease.
- Serum and CSF alpha-fetoprotein (AFP) and human chorionic gonadotropin (HCG) are also essential. Although HCG can be elevated in germinoma with syncytiotrophoblastic giant cells or HCG-secreting germinoma, if the HCG is

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Table 19.1 Suggested volumes

CTVwholeventricle	CTVboost + whole ventricles drawn on CT and thin cut T2 MRI. Include lateral, third, and fourth ventricles with suprasellar and pineal cisterns. Include prepontine cistern if large sellar tumor or s/p endoscopic third ventriculostomy (some always include the prepontine cistern) [1]
PTVwholeventricle	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)
CTVcraniospinal	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 the T2 sequence of the MRI scan [2]
PTVcraniospinal	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)
GTVboost	For boost, take into account pre-surgery and prechemotherapy size on thin cut T1 post-contrast and T2 MRI. Include resection bed and residual disease on thin cut T1 post-contrast, T2 MRI, and planning CT. If pineal lesion is seen on MRI but the patient has diabetes insipidus, assume the suprasellar region has tumor and include in boost volume
CTVboost	GTVboost + 0.5–1.0 cm
PTVboost	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)

markedly elevated, the patient should be treated as having a mixed germ cell tumor. Elevated serum or CSF concentrations of AFP raise strong suspicion of NGGCT.

- Obtain thin slice MRI brain with T1 pre- and post-gadolinium for boost target delineation and thin slice T2 and CT for ventricle contouring. Utilize the T2 spine MRI to determine the inferior field border and if craniospinal irradiation (CSI) is required. Fuse both the preoperative and postoperative MRIs to help delineate target volume. CT simulation with a thermoplastic mask and body immobilization for CSI with 1–2 mm slice thickness.
  - For CSI, treatment may be delivered either supine (more comfortable for patient and stable positioning) or prone (advantage is to visualize the spine junction match lines on the skin, if using traditional CSI technique, but uncomfortable for the patient).
  - Hyperextension of the neck can optimally spare the esophagus and larynx.

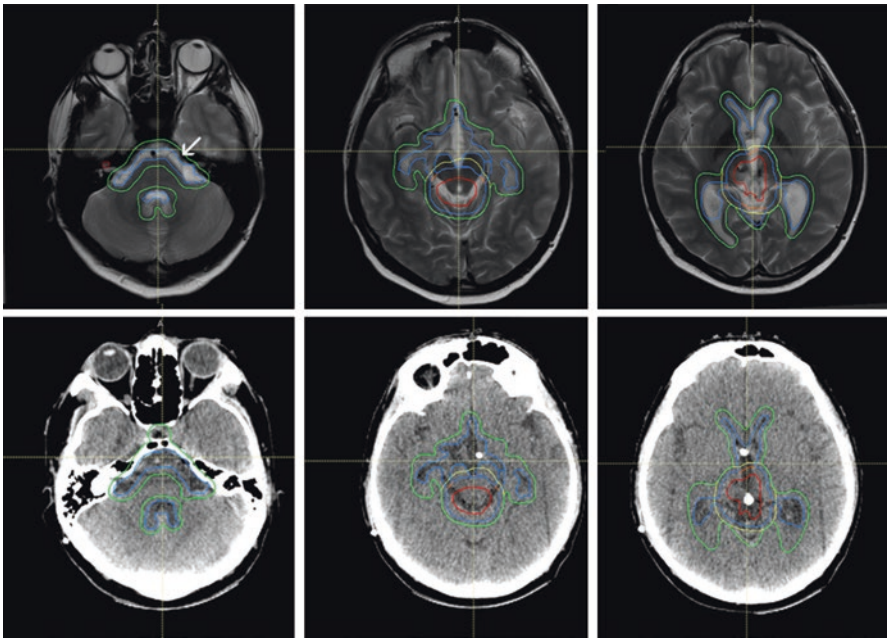

Fig. 19.1 Contours for a patient with germinoma after complete response to chemotherapy. Contours for whole ventricle RT are based on postoperative T2 MRI (upper row) and plan CT (lower row). Blue, CTVwholeventricle; green, PTVwholeventricle; red, prechemotherapy tumor extent. Prepontine cistern indicated by white arrow

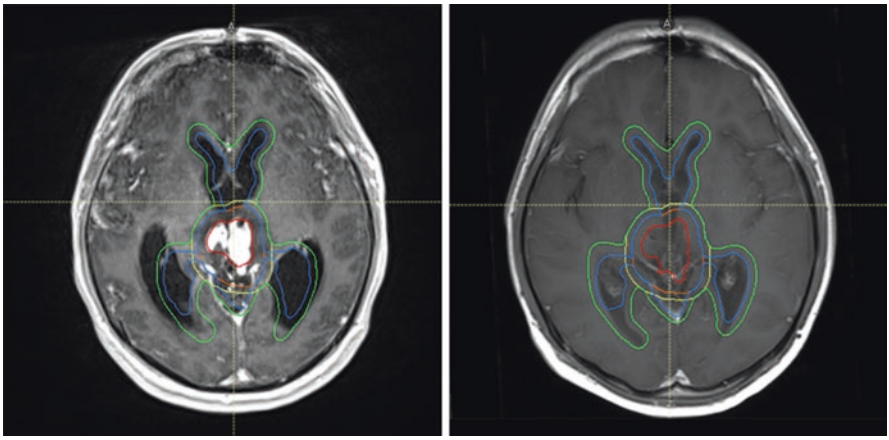

Fig. 19.2 Contours for the boost for the same patient, based on prechemotherapy (left) and post-chemotherapy T1 post-gadolinium (right) MRI. Red, pre-chemotherapy GTV; orange, CTVboost (0.5–1.0 cm expansion on GTV); blue, CTVwholeventricle; green, PTVwholeventricle

19.2 Dose Prescriptions

- M0 germinoma [6, 8]
  - With complete response to chemotherapy: Whole ventricular RT to 23.4–24 Gy in 1.5–1.8 Gy fractions, boost to 36 Gy. ACNS 1123 trial currently utilizing whole ventricular RT to 18 Gy, boost to 30 Gy.
  - With partial response to chemotherapy: Whole ventricular RT to 23.4–24 Gy in 1.5–1.8 Gy fractions, boost to 39.6–40 Gy. ACNS 1123 trial currently utilizing whole ventricular RT to 24 Gy, boost to 36 Gy.
  - With no chemotherapy: Whole ventricular RT to 23.4–24 Gy in 1.5–1.8 Gy, boost to 40–45 Gy.

    Alternatives include the University of Toronto approach: CSI to 25 Gy in 20 fractions with simultaneous integrated boost to 40 Gy in 20 fractions [3].
- M+ germinoma
  - With chemotherapy: Craniospinal RT to 23.4–24 Gy in 1.5–1.8 Gy fractions, PTVboost to 30–36 Gy for complete response and 36–40 Gy for partial response [5].
  - With no chemotherapy: Craniospinal RT to 23.4–30 Gy in 1.5–1.8 Gy, PTVboost to 45–50.4 Gy. Craniospinal RT should be 30–36 Gy if cord diffusely coated.
- M0 and M+ non-germinomatous germ cell tumor
  - Chemotherapy followed by CSI to 36 Gy in 1.8 Gy fractions, PTVboost to 54 Gy. Spinal metastases to 45 Gy [7].

19.3 Treatment Planning Techniques (Figs. 19.3 and 19.4, Table 19.2)

- For whole ventricular RT, IMRT or proton therapy may be used with the goal of sparing normal brain and bilateral cochleae:
  - For proton therapy treatment, generally three beams: right lateral, left lateral, and posterior or superior.
- For CSI, volumetric modulated arc therapy (VMAT), helical tomotherapy, or proton therapy may be used with the goal of sparing the bone marrow, heart, lungs, kidneys, and bowel for the CSI portion:
  - For further information, please see Chap. 18.
- For radiation centers not using the above techniques for CSI, traditional matched cranial and spinal fields can be used. Field junction feathering is highly recommended to minimize hot and cold spots. Gaps of 0–5 mm between the fields have been used, depending on institutional policy. The match between the cranial and upper spinal fields sometimes entails a couch kick (to eliminate divergence into the upper spinal field), a collimator rotation (to match divergence of upper spinal field), and a gantry tilt (to eliminate divergence to opposite lens) for each cranial field.
- Treatment planning aims to cover 95% of the PTV by 95% of the prescribed dose for photon plans and 100% of the CTV by 100% of the prescribed dose for proton plans.

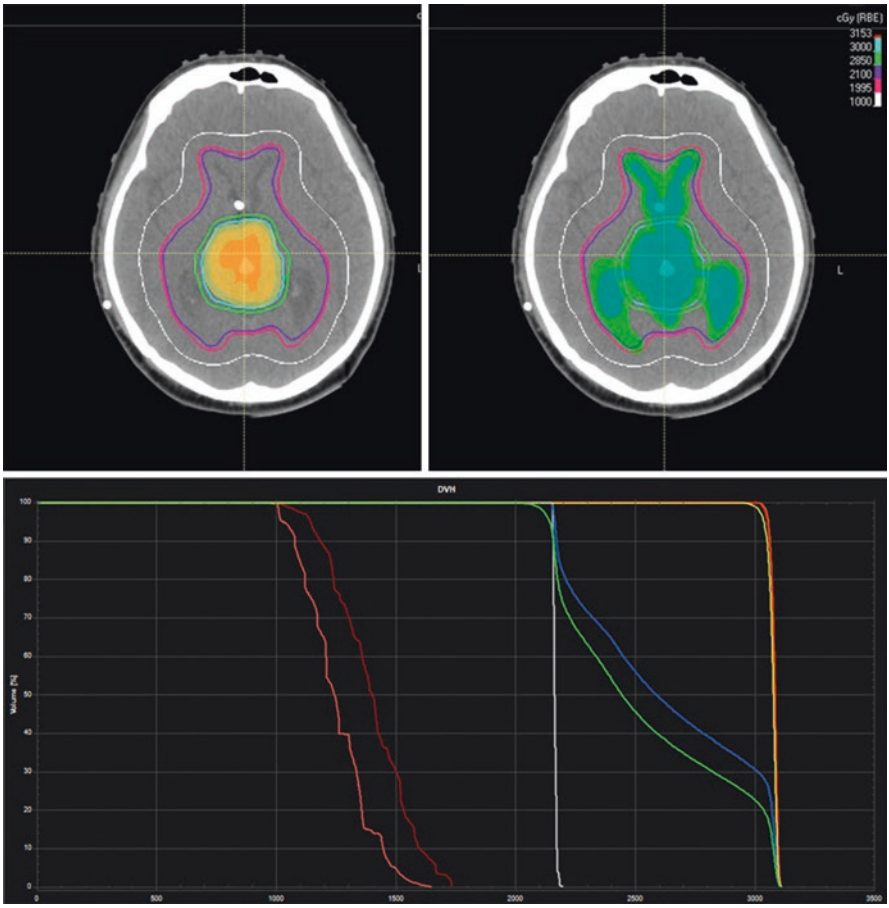

Fig. 19.3 Plan for the same patient with whole ventricles to 21 cobalt gray equivalent (CGE) and boost to 30 CGE plan utilizing proton therapy. Red, GTV; orange, CTVboost; yellow, PTVboost; blue, CTVwholeventricles; green, PTVwholeventricles. DVH shows targets in the corresponding colors described above: cochleae in peach and brown and chiasm on white

19.4 Side Effects (Table 19.3)

For CSI, recommend weekly patient weights and complete blood count with differential during treatment. Consider daily premedication with ondansetron. The exit dose of the spinal fields to the anterior structures is decreased with VMAT, helical tomotherapy, proton therapy, and the risk and extent of the above-listed complications are expected to be less. Dosimetrically, proton therapy has the best marrow sparing capability.

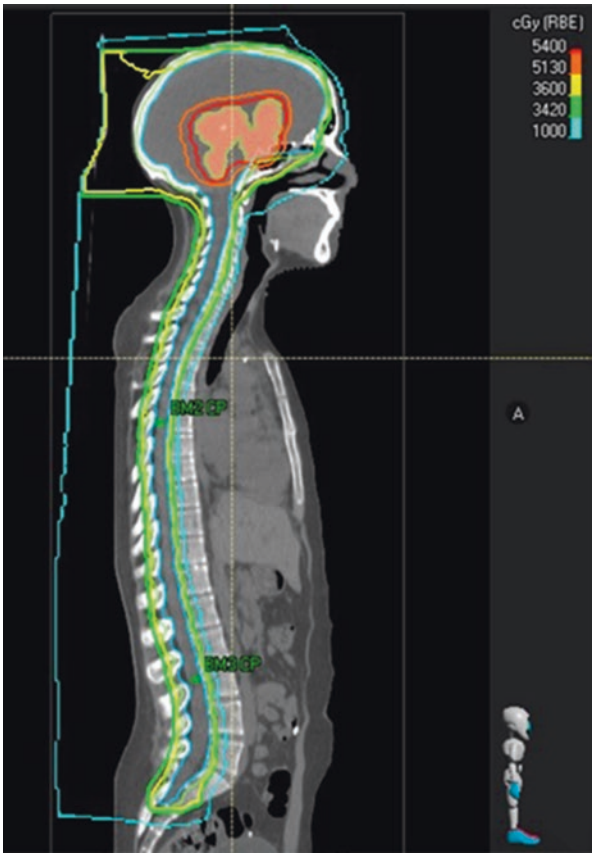

Fig. 19.4 Plan for a patient with non-germinomatous germ cell tumor utilizing proton therapy with gradient matching to deliver craniospinal irradiation to 36 CGE with boost to 54 CGE. Orange, CTVboost; yellow, PTVboost. For further details regarding craniospinal irradiation, please see Chap. 18

Table 19.2 Organs at risk

Organs at risk	Suggested dose constraints
Optic nerves and chiasm	$D_{max} < 55$ Gy
Eyes	$D_{max} < 45$ Gy
Lenses	7–10 Gy
Cochleae	$D_{max} < 35$ Gy (ALARA depending on prescription doses) [4]

Table 19.3 Side effects

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

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Further Reading

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