Glioblastoma

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Contents

15.1 General Principles of Simulation and Target Delineation

- Information on simulation
  - CT simulation with thermoplastic mask for immobilization. Contrast may be of limited value at the time of CT if high-quality MRI is available for image registration.
  - Obtain volumetric thin slice T1 pre- and post-contrast MRI including T2 and FLAIR sequences.
- Recommendations for target delineation (Tables 15.1, 15.2, and 15.3, Fig. 15.1)
  - The target is primarily defined on the postoperative MRI utilized for treatment planning, although registration of the preoperative images may be helpful to assess changing FLAIR/T2 abnormalities or in defining portions of the surgical cavity.

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Table 15.1 Suggested target volumes for glioblastoma with a two-phase approach

Target volumes	Definition and description
GTV_4600	FLAIR or T2 on postoperative MRI; include all of GTV_6000 in this volume
CTV_4600	GTV_4600 plus a variable margin for microscopic involvement. This is typically 0.5–2.0 cm. Exclude tissues from this volume that are at low risk to be infiltrated by tumor (dura, bone, across the falx, into the ventricle, unviolated tentorium)
PTV_4600	CTV_4600 plus a margin for setup error and localization. With daily KV image guidance and a thermoplastic masks, this will typically be 3–5 mm
GTV_6000	T1-enhancing tumor plus postoperative cavity
CTV_6000	GTV_6000 plus a variable margin for microscopic involvement. This is typically 0.5–2.0 cm. Exclude tissues from this volume that are at low risk to be infiltrated by tumor (dura, bone, across the falx, into the ventricle, unviolated tentorium)
PTV_6000	CTV_6000 plus a margin for setup error and localization. With daily KV image guidance and a thermoplastic mask, this will typically be 3–5 mm

Table 15.2 Suggested target volumes for glioblastoma with a single-phase approach (60 Gy in 30 fractions)

Target volumes	Definition and description
GTV_6000	T1-enhancing tumor including the postoperative cavity
CTV_6000	GTV_6000 plus a variable margin for microscopic involvement. This is typically 1.5–2.0 cm. Exclude tissues from this volume that are at low risk to be infiltrated by tumor (dura, bone, across the falx, into the ventricle, unviolated tentorium). If adjacent areas of FLAIR are considered high risk and extend beyond the expansion margin, then this can be taken into the CTV_6000 volume
PTV_6000	CTV_6000 plus a margin for setup error and localization. With daily KV image guidance and a thermoplastic mask, this will typically be 3–5 mm

For patients that cannot have an MRI due to a pacemaker, planning is based upon the postoperative CT, and an additional CTV margin of 1–2 cm should be considered

Table 15.3 Suggested target volumes for elderly glioblastoma as a hypofractionated single-phase approach (40 Gy in 15 fractions)

Target volumes	Definition and description
GTV_4000	T1-enhancing tumor including the postoperative cavity
CTV_4000	GTV_4000 plus a variable margin for microscopic involvement. This is typically 1.5–2.0 cm. Exclude tissues from this volume that are at low risk to be infiltrated by tumor (dura, bone, across the falx, into the ventricle, unviolated tentorium). If adjacent areas of FLAIR are considered high risk and extend beyond the expansion margin, then this can be taken into the CTV_4000 volume
PTV_4000	CTV_4000 plus a margin for setup error and localization. With daily KV image guidance and a thermoplastic mask, this will typically be 3–5 mm

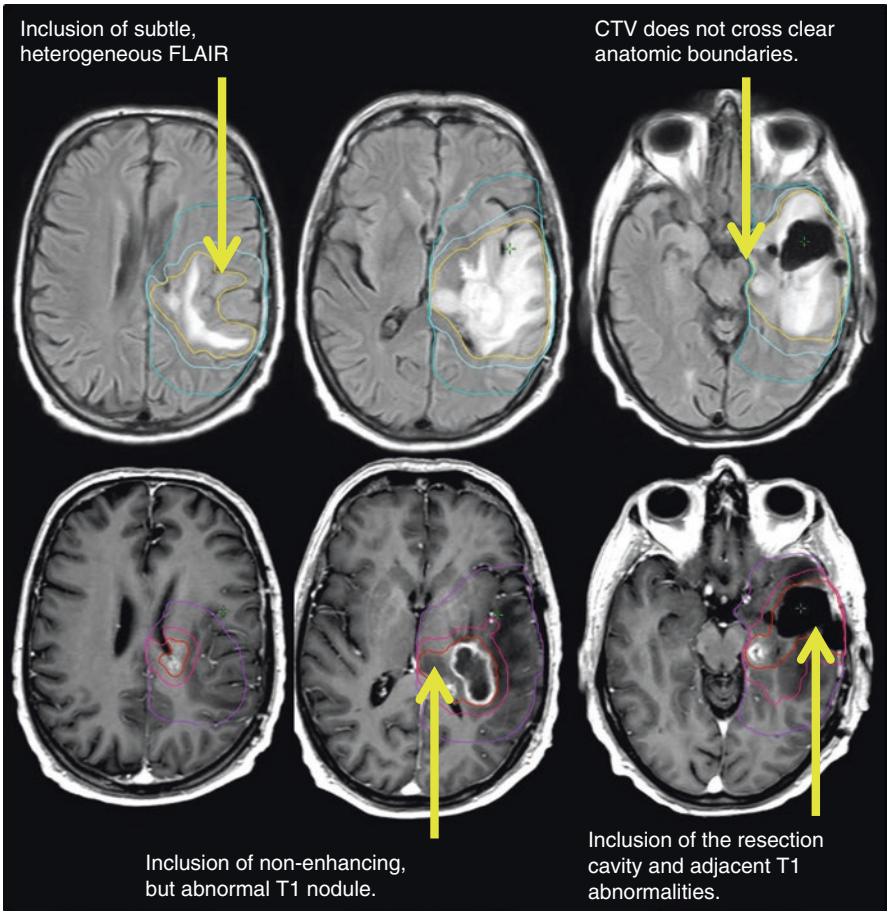

Fig. 15.1 Contours for a patient with WHO IV glioblastoma of the left temporal lobe following partial resection. The upper series shows axial T2-FLAIR images with the T2-GTV in yellow. Two approaches to CTV expansion are shown: Adult Brain Tumor Consortium (ABTC) with 0.5 cm expansion in light blue and Radiation Therapy Oncology Group (RTOG) with 2 cm expansion in green. The lower series shows the same axial slices but on the T1 contrast series with the T1-GTV in red. The ABTC boost CTV (0.5 mm expansion) is in pink. Purple represents both the RTOG boost CTV (2 cm expansion) and the European Organisation for Research and Treatment of Cancer (EORTC) single-phase CTV with 2 cm expansion

- If treatment planning is delayed more than 2–3 weeks following the postoperative MRI, consider obtaining an additional MRI for planning.
- Variation exists in practice between a two-phase approach and a single-phase approach.
- The use of functional imaging in planning GBM remains investigational (e.g., FET-PET avid areas to be boosted).

15.2 Dose Prescriptions

- Either a single- or two-phase treatment is acceptable. If a single phase for treatment is considered for glioblastoma, smaller CTV margins such as 0.5 cm have not been well-studied.
- For two-phase treatment, PTV_4600 should receive 46 Gy in 23 fractions followed by a 7-fraction boost to PTV_6000 for a total of 60 Gy in 30 fractions.
- For elderly or low-performance status patients, consider hypofractionated radiation therapy to 40 Gy in 15 fractions. Another randomized study has investigated 25 Gy in 5 fractions.

15.3 Treatment Planning Techniques

- Patients should receive 3D or IMRT plans. The role of protons for dose escalation is being studied in NRG BN001.
- Goals: PTV D95% $\geq$ 60 Gy, D0.03cc < 64 Gy.
- See Table 15.4.

Assess target coverage on the individual plans and dosimetry of the organs at risk on the sum plan. Generally, do not underdose gross tumor to achieve dose limits to normal tissue. A small portion of the PTV may be underdosed if clinically indicated.

15.4 Side Effects (Table 15.5)

On-treatment visit should include assessment of hematologic function (lymphopenia, thrombocytopenia), steroid toxicity (hyperglycemia, insomnia, oral candidiasis, proximal muscle weakness), and screening for deep venous thrombosis and oral thrush.

Table 15.4 Dose constraints

Organs at risk (in order of importance)	Suggested dose constraints
Optic nerves and chiasm	Dmax <54, up to 60 Gy if needed for tumor coverage
Brain stem below the thalamus	Dmax <54, up to 60 Gy if needed for tumor coverage
Retinae	Dmax <45 Gy
Lens	<10 Gy
Lacrimal glands	Mean <30 Gy
Pituitary	Minimize dose, consider mean <40 Gy

Table 15.5 Side effects

Acute	Hair loss, fatigue, headaches, nausea, and cerebral edema causing neurological symptoms
Long-term	Neurocognitive decline and hypopituitarism. Radiation necrosis (5%)
Uncommon or rare risks	Pseudoprogression causing neurological symptoms, vision loss, hearing loss, secondary malignancies

Further Reading

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