

APPENDIX

Normal Tissue Constraint Guidelines

The radiation dose constraints below are meant to serve as a guide only and may not be applicable to all clinical scenarios. Most doses are derived from randomized studies or consensus guidelines and we have attempted to provide the sources for these recommendations. Please refer to the individual pediatric chapters for dose constraints in the pediatric population as these can vary greatly from protocol to protocol and tend to be particularly site- and age-dependent.

What are the recommended dose constraints for the following organs and clinical scenarios?

ORGAN	CONSTRAINTS
CNS (1.8-2.0 Gy/fx)	
Spinal cord	max 50 Gy (full cord cross-section); tolerance increases by 25% 6 mos after 1 st course (for re-irradiation) (QUANTEC)
Brain	max 72 Gy (partial brain); avoid >2 Gy/fx or hyperfractionation (QUANTEC)
Chiasm/optic nerves	max 55 Gy (QUANTEC)
Brainstem	Entire brainstem <54 Gy, V59 Gy <1-10 cc (QUANTEC)
Eyes (globe)	Mean <35 Gy (RTOG 0225), max 54 Gy (RTOG 0615)
Lens	max 7 Gy (RTOG 0539)
Retina	max 50 Gy (RTOG 0539)
Lacrimal Gland	max 40 Gy (Parsons)
Inner ear/cochlea	mean ≤45 Gy (consider constraining to ≤35 Gy with concurrent cisplatin) (QUANTEC)
Pituitary gland	max 45 Gy (for panhypopituitarism, lower for GH deficiency) (Emami)
Cauda equina	Max 60 Gy (Emami)
CNS (single fraction)	
Spinal cord	max 13 Gy (if 3 fxs, max 20 Gy) (QUANTEC)

**What are the recommended dose constraints for
the following organs and clinical scenarios? (Continued)**

ORGAN	CONSTRAINTS
CNS (single fraction)	
Brain	V12 Gy <5-10 cc (QUANTEC)
Chiasm/optic nerves	max 10 Gy (QUANTEC)
Brainstem	max 12.5 Gy (QUANTEC)
Sacral plexus	V18 <0.035 cc, V14.4 <5 cc (RTOG 0631)
Cauda equina	V16 <0.035 cc, V14 <5 cc (RTOG 0631)
H&N (1.8-2.0 Gy/fx)	
Parotid gland(s)	mean <25 Gy (both glands) or mean <20 Gy (1 gland) (QUANTEC)
Submandibular gland(s)	mean <35 Gy (QUANTEC)
Larynx	mean ≤44 Gy, V50 ≤27%, max 63-66 Gy (when risk of tumor involvement is limited) (QUANTEC)
TMJ/mandible	max 70 Gy (if not possible, then V75 <1 cc) (RTOG 0615)
Oral cavity	Nonoral cavity cancer: mean <30 Gy, avoid hot spots >60 Gy (RTOG 0920) Oral cavity cancer: mean < 50 Gy, V55 <1 cc, max 65 Gy (RTOG 0920)
Esophagus (cervical)	V45 <33% (RTOG 0920)
Pharyngeal constrictors	Mean <50 Gy (QUANTEC)
Thyroid	V26 <20% (JHH)
Thoracic (1.8-2.0 Gy/fx)	
Brachial plexus	max 66 Gy, V60 <5% (RTOG 0619)
Lung (combined lung for lung cancer treatment)	mean <20-23 Gy, V20 <30%-35% (QUANTEC)
Lung (ipsilateral lung for breast cancer treatment)	V25 <10% (JHH)
Single lung (after pneumonectomy)	V5 <60%, V20 <4-10%, MLD <8 Gy (QUANTEC)
Bronchial tree	max 80 Gy (QUANTEC)
Heart (lung cancer treatment)	Heart V45 <67%; V60 <33% (NCCN 2010)
Heart (breast cancer treatment)	V25 <10% (QUANTEC)
Esophagus	V50 <32% (Maguire), V60 <33% (Emami)
Thoracic (hypofractionation)	
Spinal cord	Total recommended cumulative dose by the number of fractions per NCCN 2010. Note: the max dose limits refer to volumes >0.035 cc (~3 mm ³). 1 fraction: 14 Gy 3 fractions: 18 Gy (6 Gy/fx) 4 fractions: 26 Gy (6.5 Gy/fx) 5 fractions: 30 Gy (6 Gy/fx)

**What are the recommended dose constraints for
the following organs and clinical scenarios? (Continued)**

ORGAN	CONSTRAINTS
Esophagus	1 fraction: 15.4 Gy 3 fractions: 30 Gy (10 Gy/fx) 4 fractions: 30 Gy (7.5 Gy/fx) 5 fractions: 32.5 Gy (6.5 Gy/fx)
Brachial plexus	1 fraction: 17.5 Gy 3 fractions: 21 Gy (7 Gy/fx) 4 fractions: 27.2 Gy (6.8 Gy/fx) 5 fractions: 30 Gy (6 Gy/fx)
Heart/Pericardium	1 fraction: 22 Gy 3 fractions: 30 Gy (10 Gy/fx) 4 fractions: 34 Gy (8.5 Gy/fx) 5 fractions: 35 Gy (7 Gy/fx)
Great vessels	1 fraction: 37 Gy 3 fractions: 39 Gy (13 Gy/fx) 4 fractions: 49 Gy (12.25 Gy/fx) 5 fractions: 55 Gy (11 Gy/fx)
Trachea/Large Bronchus	1 fraction: 20.2 Gy 3 fractions: 30 Gy (10 Gy/fx) 4 fractions: 34.8 Gy (8.7 Gy/fx) 5 fractions: 40 Gy (8 Gy/fx)
Rib	1 fraction: 30 Gy 3 fractions: 30 Gy (10 Gy/fx) 4 fractions: 32 Gy (7.8 Gy/fx) 5 fractions: 32.5 Gy (6.5 Gy/fx)
Skin	1 fraction: 26 Gy 3 fractions: 30 Gy (10 Gy/fx) 4 fractions: 36 Gy (9 Gy/fx) 5 fractions: 40 Gy (8 Gy/fx)
Stomach	1 fraction: 12.4 Gy 3 fractions: 27 Gy (9 Gy/fx) 4 fractions: 30 Gy (7.5 Gy/fx) 5 fractions: 35 Gy (7 Gy/fx)
GI (1.8-2.0 Gy/fx)	
Stomach	TD 5/5 whole stomach: 45 Gy (QUANTEC)
Small bowel	V45 <195 cc (QUANTEC)
Liver (metastatic disease)	mean liver <32 Gy (liver = normal liver minus gross disease)(QUANTEC)
Liver (primary liver cancer)	mean liver <28 Gy (liver = normal liver minus gross disease) (QUANTEC)
Colon	45 Gy, max dose 55 Gy (Emami)

**What are the recommended dose constraints for
the following organs and clinical scenarios? (Continued)**

ORGAN	CONSTRAINTS
Kidney (bilateral)	mean <18 Gy, V28 <20%, V23 Gy <30%, V20 <32%, V12 <55%. If mean kidney dose to 1 kidney > 18 Gy, then constrain remaining kidney to V6 <30%. (QUANTEC)
GI (single fraction)	
Duodenum	V16 <0.035 cc, V11.2 <5 cc
Kidney (Cortex)	V8.4 <200 cc
Kidney (Hilum)	V10.6 <66%
Colon	V14.3 <20 cc, V18.4 <0.035 cc
Jejunum/Ileum	V15.4 <0.035 cc, V11.9 <5 cc
Stomach	V16 <0.035 cc, V11.2 <10 cc
Rectum	V18.4 <0.035 cc, V14.3 <20 cc
GU (1.8-2.0 Gy/fx)	
Femoral heads	V50 <5% (RTOG GU Consensus)
Rectum	V75 <15% , V70 <20%, V65 <25%, V60 <35%, V50 <50% (QUANTEC)
Bladder	V80 <15%, V75 <25%, V70 <35%, V65 <50% (QUANTEC)
Testis	V3 <50% (RTOG 0630)
Penile bulb	Mean dose to 95% of the volume <50 Gy. D70 ≤70 Gy, D50 ≤50 Gy (QUANTEC 2010)
GU (LDR prostate brachytherapy)	
Urethra	Volume of urethra receiving 150% of prescribed dose (Ur150) <30% (JHH)
Rectum	Volume of rectum receiving 100% of prescribed dose (RV100) <0.5 cc (JHH)
GYN	
Bladder point (cervical brachytherapy)	Max 80 Gy (LDR equivalent dose) (ABS 2000)
Rectal point (cervical brachytherapy)	Max 75 Gy (LDR equivalent dose) (ABS 2000)
Proximal vagina (mucosa) (cervical brachytherapy)	Max 120 Gy (LDR equivalent dose) (Hintz)
Distal vagina (mucosa) (cervical brachytherapy)	Max 98 Gy (LDR equivalent dose) (Hintz)
<p>Sources: ABS 2000: American Brachytherapy Society consensus statement for HDR brachytherapy for cervical cancer (Nag S, et al., <i>IJROBP</i>, 2000); Emami: Emami et al., <i>IJROBP</i> 31:5, 1995; Hintz: Hintz BL. et al., <i>IJROBP</i>, 1980; JHH: clinical practice at Johns Hopkins Hospital; Maguire: Maguire PD, Sibley GS, Zhou SM, et al: Clinical and dosimetric predictors of radiation-induced esophageal toxicity. <i>IJROBP</i> 45:97-103, 1999; NCCN 2010: www.nccn.org; Parsons: Parsons JT, et al., <i>Oncology</i>, 2006; QUANTEC (Quantitative Analyses of Normal Tissue Effects in the Clinic): <i>IJROBP</i>, 76 (2), Suppl, Mar 1, 2010; RTOG protocols: www.rtog.org; RTOG GU consensus: Lawton CAF et al., <i>IJROBP</i>, 2009.</p>	