

NORMAL TISSUE CONSTRAINTS FOR SRS / SBRT



Organ at Risk	Constraint	SRS / SBRT Fractions [fx]								Endpoint	References	
		1		3		4		5				8
		Optimal	Mandatory	Optimal	Mandatory	Mandatory	Optimal	Mandatory	Optimal	Mandatory		
[a] Central nervous system dose constraints												
Optic pathway	DMax (≤0.035 cm ³)	<10 Gy	<12 Gy	<17.4 Gy (5.8 Gy/fx)	<20 Gy	<21.2 Gy	—	<25 Gy (5 Gy/fx)	—	28.6 Gy	Neuritis Grade 3 or above	1, 2, 4
	DMax (0.1 cm ³)	—	<8 Gy	—	<15 Gy	—	—	<22.5 Gy	—	—	Neuritis	1, 2
Cochlea	D<0.2 cm ³	—	<8 Gy	—	<15.3 Gy (5.1 Gy/fx)	<18.2 Gy	—	<23 Gy (4.6 Gy/fx)	—	<27.2 Gy	Neuritis Grade 3 or above	2
	DMax (≤0.035 cm ³)	—	<9 Gy	—	<17.1 Gy (5.7 Gy/fx)	<18 Gy	<22 Gy	<25 Gy (5 Gy/fx)	—	<26.4 Gy	Grade 3+ hearing loss	1, 2
Brainstem (not medulla)	DMax (≤0.035 cm ³)	—	<15 Gy	—	<23.1 Gy (7.7 Gy/fx)	<27.2 Gy	—	<31 Gy (8.2 Gy/fx)	—	<37.6 Gy	Grade 3+ cranial neuropathy	1, 2
	DMax (0.1 cm ³)	<10 Gy	<15 Gy	<18 Gy	<23.1 Gy	—	<23 Gy	<31 Gy	—	<37.6 Gy	Cranial neuropathy	1, 2
Spinal canal* (including medulla)	D<0.5 cm ³	—	<10 Gy	<15.9 Gy	<18 Gy (6 Gy/fx)	<20.8 Gy	—	<23 Gy (4.6 Gy/fx)	—	<27.2 Gy	Grade 3+ myelitis (6mm et al.: 1 fx and 3 fx optimal doses to 0.1 cm ³ limit risk of grade 2-4 myelopathy to 0.4%)	1, 2, 4
	DMax (≤0.035 cm ³)	<12.4 Gy	<14 Gy	<20.3 Gy	<22.5 Gy	<25.6 Gy	<25.3 Gy	<28 Gy	—	<33.6 Gy	Grade 3+ myelitis	1
Cauda equina	DMax (0.1 cm ³)	<10 Gy	<14 Gy	<18 Gy	<21.9 Gy	—	<23 Gy	<30 Gy	<25 Gy	<32 Gy	Grade 3+ myelitis	1
	D<0.35 cm ³	—	<10 Gy	—	<18 Gy (6 Gy/fx)	<18 Gy	—	<22 Gy	—	<26.4 Gy	Myelitis	2
Spinal canal subvolume (5–6 mm above and below level treated per fx)	D1 cm ³	<7 Gy	—	<12.3 Gy	—	—	<14.5 Gy	—	—	—	Myelitis	1
	D<1.2 cm ³	—	<7 Gy	—	<12.3 Gy (4.1 Gy/fx)	—	—	<14.5 Gy (2.9 Gy/fx)	—	—	Myelitis	2
Sacral plexus	DMax (≤0.035 cm ³)	—	<16 Gy	<24 Gy (8 Gy/fx)	<25.5 Gy	<28.8 Gy	—	<31.5 Gy	—	<38.4 Gy	Grade 3+ neuritis	1, 2
	DMax (0.1 cm ³)	—	<16 Gy	—	<24 Gy	<24 Gy	—	<32 Gy	—	<32 Gy	Neuritis	1, 2
Normal brain (whole brain-gross tumour volume)	D<5 cm ³	—	<14 Gy	—	<21.9 Gy (7.3 Gy/fx)	<26 Gy	—	<30 Gy (6 Gy/fx)	—	<34 Gy	Grade 3+ neuritis	2
	D5 cm ³	—	<14 Gy	—	<22 Gy	<22 Gy	—	<30 Gy	—	<30 Gy	Neuropathy	1, 2
Normal brain (whole brain-gross tumour volume)	D10 cm ³	<12 Gy	—	—	<22 Gy	—	—	<30 Gy	—	—	Radiation necrosis	1
	D50 %	<5 Gy	—	—	—	—	—	—	—	—	Cognitive deterioration	1
Lens	DMax (0.1 cm ³)	<1.5 Gy	—	—	—	—	—	—	—	—	Cataract formation	1
	DMax (0.1 cm ³)	<8 Gy	—	—	—	—	—	—	—	—	Retinopathy	1

NOTES

[a] NOTES for CNS constraints
DMax is the near-point maximum dose, defined in this case as D0.1 cm³, which is the minimum dose to the 0.1 cm³ volume of the organ receiving the highest doses.
D1 cm³, **D5 cm³** and **D10 cm³** are the minimum doses to the specified volume of the organ (1 cm³, 5 cm³, 10 cm³) that receive the highest doses.
D50% is the median dose to the volume (equal to the minimum dose to the 50% of the volume receiving the highest doses).
 * For treatments of the spine itself, these constraints should be applied to the cord planning organ at risk volume (PRV).

[b] NOTES for Thoracic constraints
DMax is the near-point maximum dose, defined in this case as D0.5 cm³, which is the minimum dose to the 0.5 cm³ volume of the organ receiving the highest doses.
V20 Gy is the percentage volume of the organ receiving a dose of 20 Gy or higher.
D30 cm³ is the minimum dose to 30 cm³ of the organ that receives the highest doses.
 * Normal lung (lungs + gross tumour volume) constraints for the treatment of two or three lung lesions in the same patient, should follow the guidelines in general point 9 above.

References

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- 10 Normal Tissue Constraints for Abdominal and Thoracic SBRT. *Eng L., Palom, Alexander L.Chin, Maximilian Diehn et al* *Seminars in Radiation Oncology* [www.doi.org/10.1016/j.semro.2017.02.001](https://doi.org/10.1016/j.semro.2017.02.001)
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 DISCLAIMER: The information presented in this document is intended to provide an overview of normal tissue constraints for radiation therapy as found in the referenced publications. IBA is not endorsing specific actions or treatment protocols of the clinical team involved in the delivery of radiation treatment of specific patients. Healthcare professionals must always rely on their professional clinical judgment when deciding whether a patient is a candidate for radiation therapy and how to use radiation therapy and dose constraints.

Organ at Risk	Constraint	SRS / SBRT Fractions [fx]						Endpoint	References
		1	3	4	5	8	8		
		Mandatory	Optimal	Mandatory	Mandatory	Optimal	Mandatory		
[c] Gastrointestinal dose constraints									
Duodenum	DMax (≤0.035 cm ³)	<12.4 Gy	<22.2 Gy (7.4 Gy/fx)	<30 Gy	<33.2 Gy	<32 Gy (6.4 Gy/fx)	<35 Gy	Grade 3+ ulceration	1, 2
	DMax (0.03 cm ³)	—	—	<24 Gy	—	—	<32 Gy	Ulcer, bleeding, perforation (Grade 3 or higher)	3
Stomach	V15 Gy	—	—	<5 cm ³	—	—	—	Ulcer, bleeding, perforation (Grade 3 or higher)	3
	V16.2 Gy	—	—	—	—	—	<5 cm ³	Ulceration	2, 3
Small bowel/jejunum/ileum	DMax (0.5 cm ³)	—	—	<22.2 Gy	—	—	<35 Gy	—	1
	D1 cm ³	—	—	<30 Gy	—	<33 Gy	<35 Gy	—	1, 3
Colon	D<5 cm ³	<11.2 Gy	—	<16.5 Gy (5.5 Gy/fx)	—	—	<18 Gy (3.6 Gy/fx)	Ulceration	2
	D5 cm ³	—	<18.5 Gy	<22.5 Gy	<25 Gy	<25 Gy	<26.5 Gy	Ulceration	1, 2
Common bile duct	D<10 cm ³	<9 Gy	—	<11.4 Gy (3.8 Gy/fx)	—	—	<12.5 Gy (2.5 Gy/fx)	—	1
	D10 cm ³	—	—	<11.4 Gy	—	—	<25 Gy	—	1
Esophagus	DMax (≤0.035 cm ³)	<12.4 Gy	<22.2 Gy (7.4 Gy/fx)	<30 Gy	<33.2 Gy	<32 Gy (6.4 Gy/fx)	<35 Gy	Grade 3+ ulceration/fistulation	1, 2
	DMax (0.5 cm ³)	—	—	<22.2 Gy	—	<33 Gy	<35 Gy	Ulceration/fistula	1, 2
Rectum	D5 cm ³	—	—	<22.5 Gy	<25 Gy	<25 Gy	<26.5 Gy	Ulceration/fistula	1, 2
	D10 cm ³	<11.2 Gy	—	<16.5 Gy (5.5 Gy/fx)	—	—	<18 Gy (3.6 Gy/fx)	—	2
Small bowel/jejunum/ileum	D10 cm ³	—	—	<16.5 Gy	—	—	<25 Gy	—	1
	D50 cm ³	—	—	—	—	—	—	—	1
Large bowel	DMax (≤0.035 cm ³)	<15.4 Gy	<25.2 Gy (8.4 Gy/fx)	<28.5 Gy	<31.6 Gy	—	<34.5 Gy	Grade 3+ enteritis/obstruction	1, 2
	DMax (0.03 cm ³)	—	—	<27 Gy	—	—	<35 Gy	Ulcer, bleeding, perforation (Grade 3 or higher)	3
Rectum	V18 Gy	—	—	<5 cm ³	—	—	—	Ulcer, bleeding, perforation (Grade 3 or higher)	3
	V19.5 Gy	—	—	—	—	—	<5 cm ³	Enteritis/obstruction	2, 3
Rectum	DMax (0.5 cm ³)	—	—	<25.2 Gy	—	<30 Gy	<35 Gy	—	1
	D2 cm ³	—	—	<24.5 Gy	—	—	<30 Gy	—	3
Rectum	D<5 cm ³	<11.9 Gy	—	<17.7 Gy (5.9 Gy/fx)	—	—	<19.5 Gy (3.9 Gy/fx)	—	2
	D5 cm ³	—	—	<17.7 Gy <21 Gy	—	<25 Gy	<25 Gy	—	1, 3
Colon	D10 cm ³	—	—	—	—	—	<25 Gy	—	1
	DMax (≤0.035 cm ³)	<18.4 Gy	—	<28.2 Gy (8.4 Gy/fx)	<48.5 Gy	<38 Gy (7.6 Gy/fx)	52.5 Gy	Colitis/fistula	2
Common bile duct	D<20 cm ³	<14.3 Gy	—	<24 Gy (8 Gy/fx)	<30.8 Gy	<25 Gy (5 Gy/fx)	32.5 Gy	—	2
	DMax (≤0.035 cm ³)	—	—	<38 Gy	<38.4 Gy	—	<41 Gy	Stenosis	1, 2
Esophagus	DMax (0.03 cm ³)	—	—	—	—	—	<35 Gy	Grade 3+ stenosis/fistula	1, 3
	DMax (≤0.035 cm ³)	<15.4 Gy	<25.2 Gy (8.4 Gy/fx)	<32.4 Gy	<35.6 Gy	<35 Gy (7 Gy/fx)	<38 Gy	Grade 3+ stenosis/fistula (Grade 3 or higher)	2, 3
Rectum	DMax (0.03 cm ³) for Grade 2 esophagitis	—	—	<27 Gy	—	—	<35 Gy	Stenosis/fistula (Grade 3 or higher)	3
	DMax (0.03 cm ³) for Grade 3 or higher	—	—	—	—	—	<50 Gy	Stenosis/fistula	2, 3
Rectum	DMax (0.5 cm ³)	—	—	<25.2 Gy	—	<32 Gy	<34 Gy	—	1
	D2 cm ³	<14 Gy	—	—	—	—	—	—	3
Rectum	D<5 cm ³	<11.9 Gy	<17.7 Gy (5.9 Gy/fx)	<27.9 Gy	30.4 Gy	<19.5 Gy (3.9 Gy/fx)	<32.5 Gy	—	2, 3
	V27.5 Gy	—	—	—	—	—	<5 cm ³	—	3
Rectum	DMax (0.5 cm ³)	—	—	<28.2 Gy	—	—	<32 Gy	Grade 3+ colitis/fistula	1
	DMax (≤0.035 cm ³)	<18.4 Gy	<28.2 Gy (8.4 Gy/fx)	—	—	<38 Gy (7.6 Gy/fx)	<38 Gy	Grade 3+ colitis/fistula	1, 2
Rectum	DMax (0.5 cm ³)	—	—	<28.2 Gy	—	—	<32 Gy	Proctitis/fistula	1, 2
	D<20 cm ³	<14.3 Gy	—	<24 Gy (8 Gy/fx)	—	—	<25 Gy (5 Gy/fx)	—	2
Normal liver (non cirrhotic) (liver - gross tumour volume)	D700 cm ³	<8.1 Gy	—	<17.7 Gy	<18.6 Gy	<21 Gy (4.2 Gy/fx)	<21.5 Gy	Grade 3+ liver function dysfunction/radiation-induced liver disease (classic or non-classic)	1, 2, 3
	V10 Gy	—	—	—	—	—	<70%	Basic liver function (Grade 3 or higher)	1, 3
Normal liver (non cirrhotic) (liver - gross tumour volume)	Mean dose	—	—	<13 Gy	—	<13 Gy	<15.2 Gy	Basic liver function (Grade 3 or higher)	1, 3, 4
	D50 %	—	<15 Gy	—	—	—	—	Basic liver function	1, 2
Normal liver (non cirrhotic) (liver - gross tumour volume)	Dose to ≥ 700 cm ³	—	<15 Gy	<18 Gy <150y	—	—	<21 Gy	Basic liver function	1, 3
	Dose to ≥ 700 cm ³ DMax (0.03 cm ³)	<8.1 Gy	—	<17.1 Gy	—	—	<21 Gy	Basic liver function (Grade 3 or higher)	3
Normal liver (non cirrhotic) (liver - gross tumour volume)	Dose to ≥ 700 cm ³ DMax (0.03 cm ³)	<8.1 Gy	—	<17.1 Gy	—	—	<21 Gy	Basic liver function (Grade 3 or higher)	3
	Child Pugh Class A: ≥ 700 cm ³ of uninvolved liver	—	—	<15 Gy	—	—	<15 Gy	Basic liver function (Grade 3 or higher)	3
Central liver	Child Pugh Class A: Mean liver dose	—	—	<15 Gy	—	—	<15 Gy	—	3, 4
	Child Pugh Class B: ≥ 700 cm ³ of uninvolved liver	—	—	—	—	—	<15 Gy	—	3
Central liver	Child Pugh Class B: ≥ 500 cm ³ of uninvolved liver	—	—	—	—	—	<7 Gy	—	3
	Child Pugh Class B: Mean liver dose	—	—	—	—	—	<10 Gy	—	3
Kidneys (individual and combined)	V26 Gy	—	—	—	—	—	<40 cm ³	Hepatobiliary toxicity (Grade 3 or higher)	3
	V21 Gy	—	—	—	—	—	<37 cm ³	—	3
Kidneys (individual and combined)	Mean dose	—	—	—	—	—	<19 Gy	—	3
	Dose to ≥ 200 cm ³ **	—	—	<18 Gy	—	—	—	Grade 3+ renal function dysfunction	1
Renal cortex (right and left)	D200 cm ³	<8.4 Gy	—	<14.7 Gy	<16 Gy	—	<17.5 Gy (3.5 Gy/fx)	Basic renal function	2
	**If solitary kidney or if 1 kidney mean dose >10 Gy*	—	—	—	—	—	<10%	Grade 3+ renal function dysfunction	1
Renal hilum/vascular trunk	DMax (≤0.035 cm ³)	<18.6 Gy (6.2 Gy/fx)	—	—	—	—	—	Malignant/hypertension	2
	<2/3 volume	<2/3 volume	<2/3 volume	<2/3 volume	<2/3 volume	<2/3 volume	<23 Gy (4.6 Gy/fx)	—	2
Bladder/bladder wall	D15 cm ³	<11.4 Gy	<18.8 Gy (5.8 Gy/fx)	<17 Gy	<18.5 Gy	<18.3 Gy (3.65 Gy/fx)	<20 Gy	Grade 3+ cystitis/fistula	1, 2
	D15 cm ³	—	—	<18 Gy	—	—	<18.3 Gy	Cystitis/fistula	2
Penile bulb	DMax (0.5 cm ³)</								