

# 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			
<b>[a] Central nervous system dose constraints</b>													
Optic pathway	DMax (≤0.035cm³)	—	<10 Gy	—	<17.4 Gy (5.8 Gy/fx)	—	—	<25 Gy (5 Gy/fx)	—	—	AAPM: grade 3+ optic neuritis [3 fx: 0.8% and 5 fx: 1.6% risk grade 4 radiation-induced optic neuropathy when limited to 0.05 cm³]	1,2	
	DMax (0.1 cm²)	—	<8 Gy	—	<15 Gy	—	—	<22.5 Gy	—	—	Neuritis	1,2	
Cochlea	D<0.2 cm²	—	<8 Gy	—	<15.3 Gy (5.1 Gy/fx)	—	—	<23 Gy (4.8 Gy/fx)	—	—		2	
	DMax (≤0.035cm³)	—	<9 Gy	—	<17.1 Gy (5.7 Gy/fx)	—	—	<25 Gy (5 Gy/fx)	—	—	AAPM: grade 3+ hearing loss	1,2	
Brainstem (not medulla)	Mean	<4 Gy	<9 Gy	—	<17.1 Gy	—	—	<25 Gy	—	—	Hearing loss	1,2	
	DMax (≤0.035cm³)	—	<15 Gy	—	<23.1 Gy (7.7 Gy/fx)	—	—	<31 Gy (8.2 Gy/fx)	—	—	Grade 3+ cranial neuropathy	1,2	
	DMax (0.1 cm²)	<10 Gy	<15 Gy	<18 Gy	<23.1 Gy	—	—	<31 Gy	—	—	Cranial neuropathy	1,2	
	D<0.5 cm²	—	<10 Gy	—	<18 Gy (6 Gy/fx)	—	—	<23 Gy (4.8 Gy/fx)	—	—		2	
Spinal canal* (including medulla)	DMax (≤0.035cm³)	—	<14 Gy	—	<21.8 Gy (7.3 Gy/fx)	—	—	<30 Gy (6 Gy/fx)	—	—	AAPM: grade 3+ myelitis (Grimm et al.: 1fx and 3fx optimal doses to 0.1cm³ limit risk of grade 2-4 myelopathy to 0.4%)	1,2	
	DMax (0.1 cm²)	<10 Gy	<14 Gy	<18 Gy	<21.9 Gy	—	<23 Gy	<30 Gy	<25 Gy	<32 Gy	AAPM: grade 3+ myelitis	1	
	D<0.35 cm²	—	<10 Gy	—	<18 Gy (6 Gy/fx)	—	—	<23 Gy (4.8 Gy/fx)	—	—	Myelitis	2	
	D1 cm²	<7 Gy	—	<12.3 Gy	—	—	<14.5 Gy	—	—	—		1	
Spinal canal subvolume (5 – 6 mm above and below level treated per fcy)	D<1.2 cm²	—	<7 Gy	—	<12.3 Gy (4.1 Gy/fx)	—	—	<14.5 Gy (2.9 Gy/fx)	—	—		2	
	DMax (≤0.035cm³)	—	<14 Gy	—	<21.9 Gy (7.3 Gy/fx)	—	—	<30 Gy (6 Gy/fx)	—	—	Myelitis	2	
	D<10% of subvolume	—	<10 Gy	—	<18 Gy (6 Gy/fx)	—	—	<23 Gy (4.8 Gy/fx)	—	—		2	
	DMax (≤0.035cm³)	—	<16 Gy	—	<24 Gy (8 Gy/fx)	—	—	<32 Gy (8.4 Gy/fx)	—	—	Grade 3+ neuritis	1,2	
Cauda equina	DMax (0.1 cm²)	—	<16 Gy	—	<24 Gy	—	—	<32 Gy	—	—	Neuritis	1,2	
	D<5 cm²	—	<14 Gy	—	<21.9 Gy (7.3 Gy/fx)	—	—	<30 Gy (6 Gy/fx)	—	—		2	
	D5 cm²	—	<14 Gy	—	<22 Gy	—	—	<30 Gy	—	—		1	
	DMax (≤0.035cm³)	—	<16 Gy	—	<24 Gy (8 Gy/fx)	—	—	<32 Gy (8.4 Gy/fx)	—	—	Grade 3+ neuritis	1,2	
Sacral plexus	DMax (0.1 cm²)	—	<16 Gy	—	<24 Gy	—	—	<32 Gy	—	—	Neuropathy	1,2	
	D<5 cm²	—	<14.4 Gy	—	<22.5 Gy (7.5 Gy/fx)	—	—	<30 Gy (6 Gy/fx)	—	—		2	
	D5 cm²	—	<14 Gy	—	<22 Gy	—	—	<30 Gy	—	—		1	
	D10 cm²	<12 Gy	—	—	—	—	—	—	—	—	Radiation necrosis	1	
Normal brain (whole brain-gross tumour volume)	D50%	<5 Gy	—	—	—	—	—	—	—	—	Cognitive deterioration	1	
	DMax (0.1 cm²)	<1.5 Gy	—	—	—	—	—	—	—	—	Cataract formation	1	
Lens	DMax (0.1 cm²)	<8 Gy	—	—	—	—	—	—	—	—	Retinopathy	1	
Orbit	DMax (0.1 cm²)	<8 Gy	—	—	—	—	—	—	—	—		1	
<b>[b] Thoracic dose constraints</b>													
Breschial plexus	DMax (≤0.035cm³)	—	<17.5 Gy	—	<24 Gy (8 Gy/fx)	—	—	<30.5 Gy (6.1 Gy/fx)	—	—	Grade 3+ neuropathy	1,2	
	DMax (0.5 cm²)	—	—	<24 Gy	<26 Gy	—	<27 Gy	<29 Gy	<27 Gy	<38 Gy	Neuropathy	1,2	
	D<3 cm²	—	<14 Gy	—	<20.4 Gy (6.8 Gy/fx)	—	—	<27 Gy (5.4 Gy/fx)	—	—		2	
Heart/pericardium	DMax (≤0.035cm³)	—	<22 Gy	—	<30 Gy (10 Gy/fx)	—	—	<38 Gy (7.6 Gy/fx)	—	—	Grade 3+ pericarditis	1,2	
	DMax (0.5 cm²)	—	<26 Gy	<24 Gy	<26 Gy	—	<27 Gy	<29 Gy	<50 Gy	<60 Gy	Pericarditis	1,2	
Trachea and (large) bronchus	D<15 cm²	—	<18 Gy	—	<24 Gy (8 Gy/fx)	—	—	<32 Gy (8.4 Gy/fx)	—	—		2	
	DMax (≤0.035cm³)	—	<20.2 Gy	—	<30 Gy (10 Gy/fx)	—	—	<40 Gy (8 Gy/fx)	—	—	Grade 3+ stenosis/fistula	1,2	
	DMax (0.03 cm²)	—	—	—	<52.5 Gy	—	—	<38 Gy (1 <52.5 Gy)	—	—	Stenosis/fistula (Grade 3 or higher)	3	
	DMax (0.5 cm²)	—	—	<30 Gy	<32 Gy	—	<32 Gy	<35 Gy	<32 Gy	<44 Gy	Stenosis/fistula (Grade 3 or higher)	1,3	
D<4 cm²	V18 Gy	—	<10.5 Gy	—	<15 Gy (5 Gy/fx)	—	—	<18.5 Gy (3.3 Gy/fx)	—	—	Stenosis/fistula	2	
	V33.5 Gy (attenuation for steep dose gradient across airway)	—	—	—	<4 cm²	—	—	<4 cm²	—	—		3	
	D<10 cm²	—	<10.5 Gy	—	<15 Gy (5 Gy/fx)	—	—	<18.5 Gy (3.3 Gy/fx)	—	—		3	
	D<15 cm²	—	<10.5 Gy	—	<15 Gy (5 Gy/fx)	—	—	<18.5 Gy (3.3 Gy/fx)	—	—		3	
Bronchus-smaller airways	DMax (≤0.035cm³)	—	<13.3 Gy	—	<23.1 Gy (7.7 Gy/fx)	—	—	<33 Gy (8.6 Gy/fx)	—	—	Stenosis with atelectasis	2	
	D<0.5 cm²	—	<12.4 Gy	—	<18.9 Gy (6.3 Gy/fx)	—	—	<21 Gy (4.2 Gy/fx)	—	—		2	
Normal lungs* (lungs - gross tumour volume) (left and right)	V20 Gy	—	—	<10%	<10%	—	<10%	<10%	<10%	<10%	Grade 3+ pneumonitis	1,3	
	V20 Gy (Volume of ipsilateral organ)	—	—	<16%	<16%	—	—	—	—	—	Pneumonitis (Grade 3 or higher)	3	
	Mean Lung Dose	—	—	—	±8 Gy	—	—	—	—	—	Pneumonitis (Grade 3 or higher)	3	
	D1000 cm²	—	<7.4 Gy	—	<12.4 Gy (3.1 Gy/fx)	—	—	<13.5 Gy (2.7 Gy/fx)	—	—	Basic Lung Function, Pneumonitis	2	
Chest wall/rib	D<1000 cm² of uninvolved lung	—	—	—	—	—	—	<13.5 Gy	—	—		3	
	D1500 cm²	—	<7 Gy	—	<11.6 Gy (2.9 Gy/fx)	—	—	<12.5 Gy (2.5 Gy/fx)	—	—		2	
	DMax (≤0.035cm³)	—	<30 Gy	—	<36.9 Gy (12.3 Gy/fx)	—	—	<43 Gy (8.6 Gy/fx)	—	—	Grade 3+ fracture or pain	1,2	
	DMax (0.5 cm²)	—	<37 Gy	—	<43 Gy	—	<39 Gy	<39 Gy	<39 Gy	<39 Gy	Pain or fracture	1,2	
Great vessels	D<1 cm²	—	<22 Gy	—	<28.8 Gy (9.6 Gy/fx)	—	—	<35 Gy (7 Gy/fx)	—	—		2	
	D<30 cm²	—	—	—	<30 Gy (10 Gy/fx)	—	—	—	—	—		2	
	D30 cm²	—	—	<30 Gy	—	—	<32 Gy	—	<35 Gy	—		1	
	DMax (≤0.035cm³)	—	<37 Gy	—	<45 Gy (15 Gy/fx)	—	—	<53 Gy (10.6 Gy/fx)	—	—	Grade 3+ aneurysm	1,2	
Renal cortex (right and left)	DMax (0.03 cm²)	—	—	—	—	—	—	<53 Gy	—	—	Aneurysm (Grade 3 or higher)	3	
	DMax (0.03 cm²) to pulmonary artery	—	—	—	<52.5 Gy	—	—	<52.5 Gy	—	—	Aneurysm (Grade 3 or higher)	3	
	DMax (0.03 cm²) to aorta	—	—	—	<60 Gy	—	—	<60 Gy	—	—		2,3	
	DMax (0.5 cm²)	—	—	—	<45 Gy	—	—	<53 Gy	—	—		1	
Renal hilum/vascular trunk	V47 Gy	—	—	—	—	—	—	<10 cm²	—	—		3	
	D<10 cm²	—	<31 Gy	—	<39 Gy (13 Gy/fx)	—	—	<47 Gy (8.4 Gy/fx)	—	—		2	

## 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, 0.5 cm² and D10 cm²** are the minimum doses to the specified volume of the organ (1 cm³, 5 cm², 10 cm²) 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 cm²** is the minimum dose to 30 cm² of the organ that receives the highest doses.  
 \* Normal lung (lungs e 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.

**[c] NOTES for Gastrointestinal 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.  
**D1 cm³, 0.5 cm², D3 cm², D10 cm² and D50 cm²** are the minimum doses to the specified volume of the organ (1 cm³, 5 cm², etc.) that receive the highest doses.  
**V10 Gy** is the percentage volume of the organ receiving a dose of 10 Gy or higher.  
 Dose to 700 cm² and 200 cm² is the maximum dose to the specified volume of the organ (700 cm², 200 cm²) that receives the lowest doses.

**[d] NOTES for Pelvic 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.  
**D3 cm² and D15 cm²** are the minimum doses to the specified volume of the organ (3 cm², 15 cm²) that receive the highest doses.  
 \* If total kidney volume <200 cm³, or treating renal or adrenal lesions, then total dose to contralateral kidney should be <16 Gy and aim to minimise spillage into ipsilateral kidney if

**[e] NOTES for other tissue 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.  
**D10 cm²** is the minimum dose to the 10 cm² of the organ that receive the highest doses.

**[f] NOTES for PACE trial constraints**  
**D5%, D20%, D40% and D50%** are the minimum doses to the percentage volume of the organ (5%, 20%, etc.) that receive the highest doses.  
**D50%** is equivalent to the median dose to the volume.  
**D1 cm³ and D5 cm³** are the minimum doses to the specified volume of the organ (1 cm³, 5 cm³) that receive the highest doses.  
**V37 Gy** is the absolute volume of the organ receiving a dose of 37 Gy or higher.

## References

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Organ at Risk	Constraint	SRS / SBRT Fractions (fx)					Endpoint	References
		1	3		5			
		Mandatory	Optimal	Mandatory	Optimal	Mandatory		
<b>[c] Gastrointestinal dose constraints</b>								
Duodenum	DMax (≤0.035cm³)	<12.4 Gy	—	<22.2 Gy (7.4 Gy/fx)	—	<32 Gy (8.4 Gy/fx)	Grade 3+ ulceration	1,2
	DMax (0.03 cm²)	—	—	<24 Gy	—	<32 Gy	Ulcer, bleeding, perforation (Grade 3 or higher)	3
	V15 Gy	—	—	<5 cm³	—	—	Ulcer, bleeding, perforation (Grade 3 or higher)	3
	V16.2 Gy	—	—	—	—	<5 cm³	Ulceration	2,3
Stomach	DMax (0.5 cm²)	—	—	<22.2 Gy	—	<35 Gy		1
	D1 cm²	—	—	<30 Gy	<33 Gy	<35 Gy		1,3
	D<5 cm²	<11.2 Gy	—	<16.5 Gy (5.5 Gy/fx)	—	<18 Gy (3.8 Gy/fx)		2
	D5 cm²	—	—	<16.5 Gy	<25 Gy	—		1
Small bowel/jejunum/ileum	D8 cm²	—	—	—	<15 Gy	—		1
	D<10 cm²	<9 Gy	—	<11.4 Gy (3.8 Gy/fx)	—	<12.5 Gy (2.5 Gy/fx)		2
	D10 cm²	—	—	<11.4 Gy	—	<25 Gy		1
	DMax (≤0.035cm³)	<12.4 Gy	—	<22.2 Gy (7.4 Gy/fx)	—	<32 Gy (8.4 Gy/fx)	Grade 3+ ulceration/fistulation	1,2
Colon	DMax (0.5 cm²)	—	—	<22.2 Gy	<33 Gy	<35 Gy	Ulceration/fistula	1,2
	D5 cm²	—	—	<25 Gy	<25 Gy	—		1
	D<10 cm²	<11.2 Gy	—	<16.5 Gy (5.5 Gy/fx)	—	<18 Gy (3.8 Gy/fx)		2
	D10 cm²	—	—	<16.5 Gy	—	<25 Gy		1
Common bile duct	D50 cm²	—	—	—	—	—		1
	DMax (≤0.035cm³)	<15.4 Gy	—	<25.2 Gy (8.4 Gy/fx)	—	<35 Gy (7 Gy/fx)	Grade 3+ enteritis/obstruction	1,2
	DMax (0.03 cm²)	—	—					