Plan evaluation of brain tumors
ICRO teaching course

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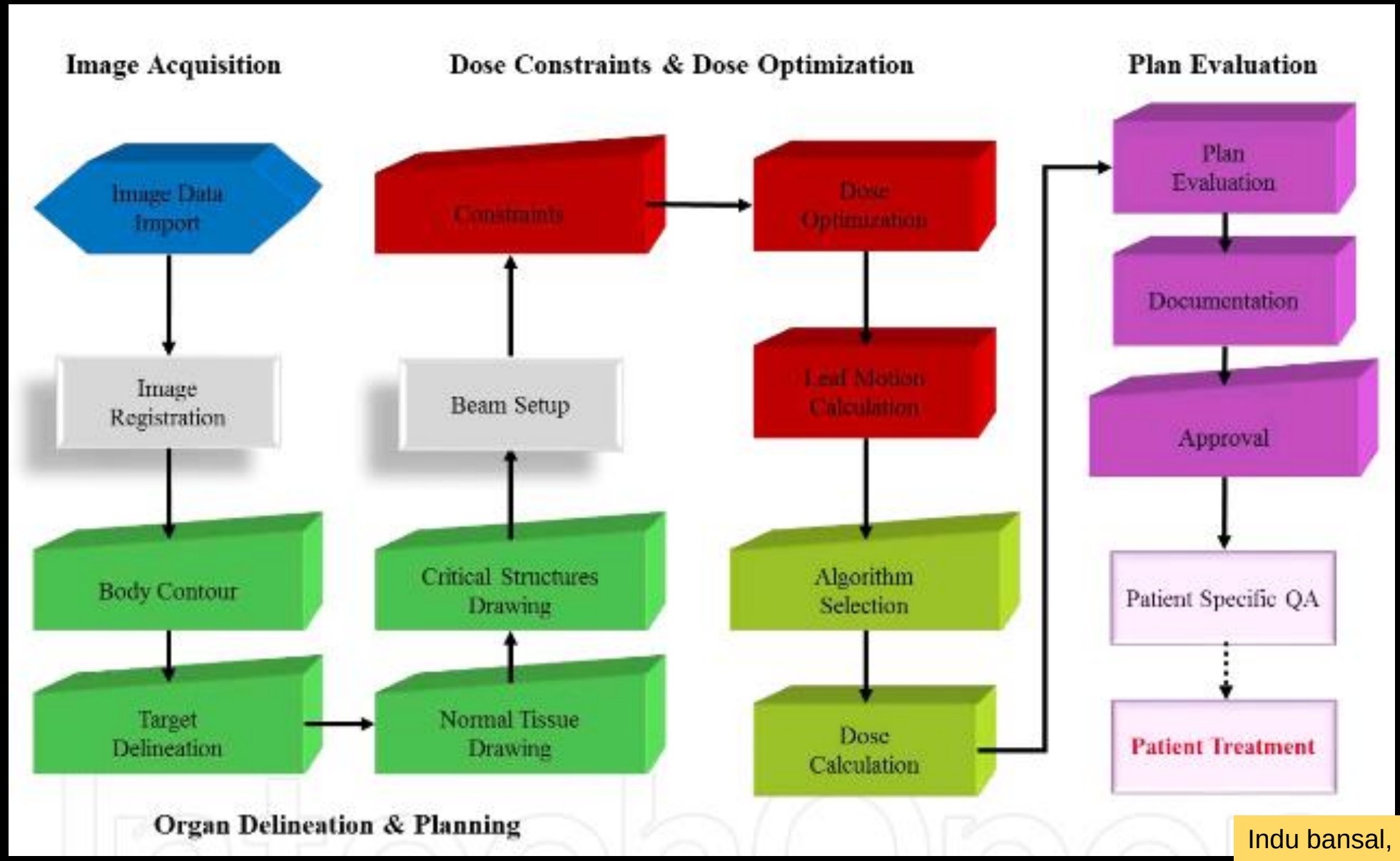
7.2.21

Radiation planning process



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Why do we need to learn plan evaluation ?

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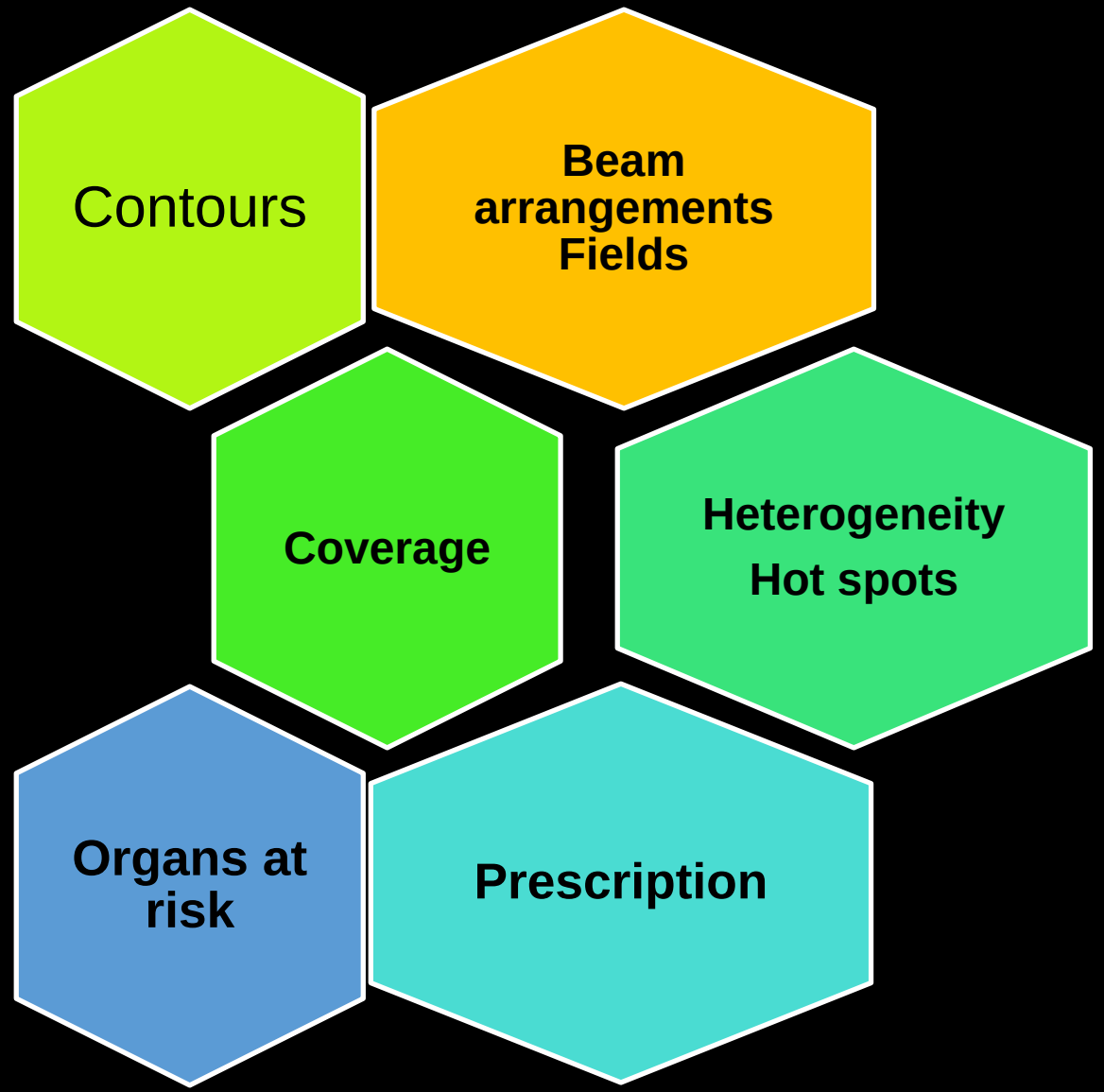
CB-CHOP


Contours
Beam arrangements Fields
Coverage
Heterogeneity Hot spots
Organs at risk
Prescription

First review delineated target volumes and organs at risk.

A normal structure may have been forgotten or not contoured

Isodose lines may spill into an OAR initially thought to be not at risk

Opportunity to check targets for accuracy and any expansions.

GTV might have been expanded but not the CTV/PTV

Why is it important to review contours again ?

- The contours are usually drawn by residents who may not be well versed with normal and abnormal contours.
- RO is a very demanding branch with lot of work going on at multiple levels.
- Contours are site specific and may vary from organ to organ and may be patient specific.

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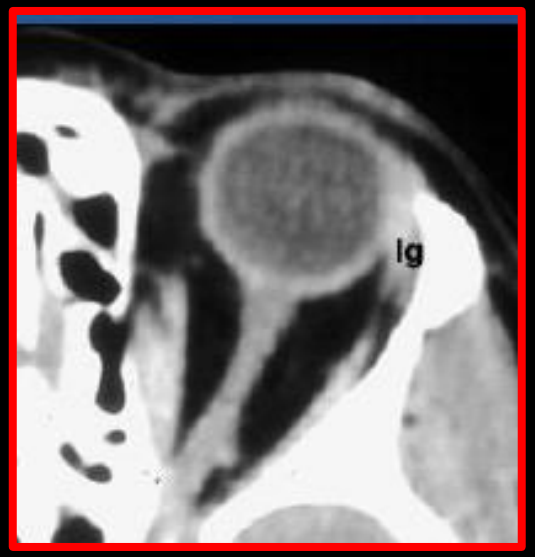
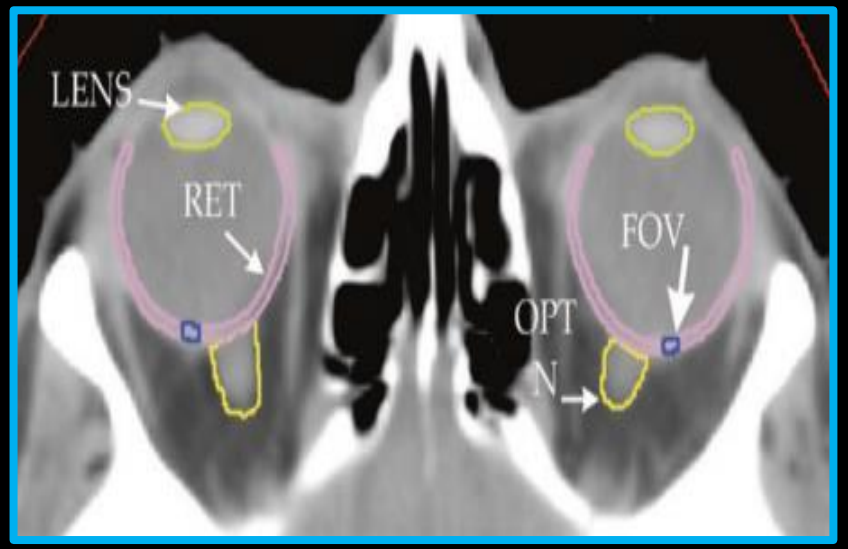
Retina, scalp, Lacrimal gland

Lacrimal gland

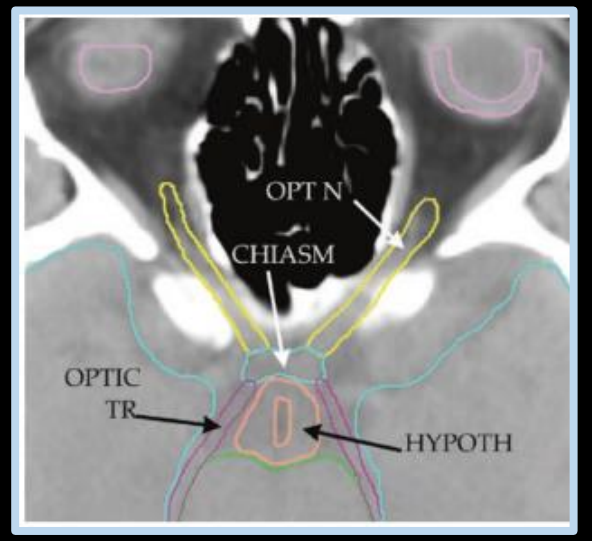


Retina



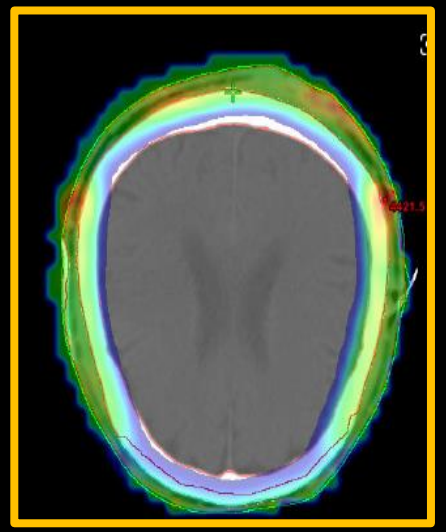
Compared to the rest of the retina, it is the only area of the retina where 20/20 vision is attainable and critical for seeing fine detail and colour.
It is employed for accurate vision in the direction where it is pointed. It comprises less than 1% of retinal size but takes up over 50% of the visual cortex

Optic tracts



From chiasm to lat. geniculate nucleus of thalamus

Total scalp



Total scalp RT
Lymphoma
Angiosarcoma
Mycosis fungoides
Basal cell ca.
squamous cell

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Caivano 2015Ann Palliat Med ;4(1):35-38

Hippocampus

Periventricular and peri-granular zones of hippocampus sites for neurogenesis

A) Parahippocampal gyrus

B) Temporal horn

C)Ambient cistern

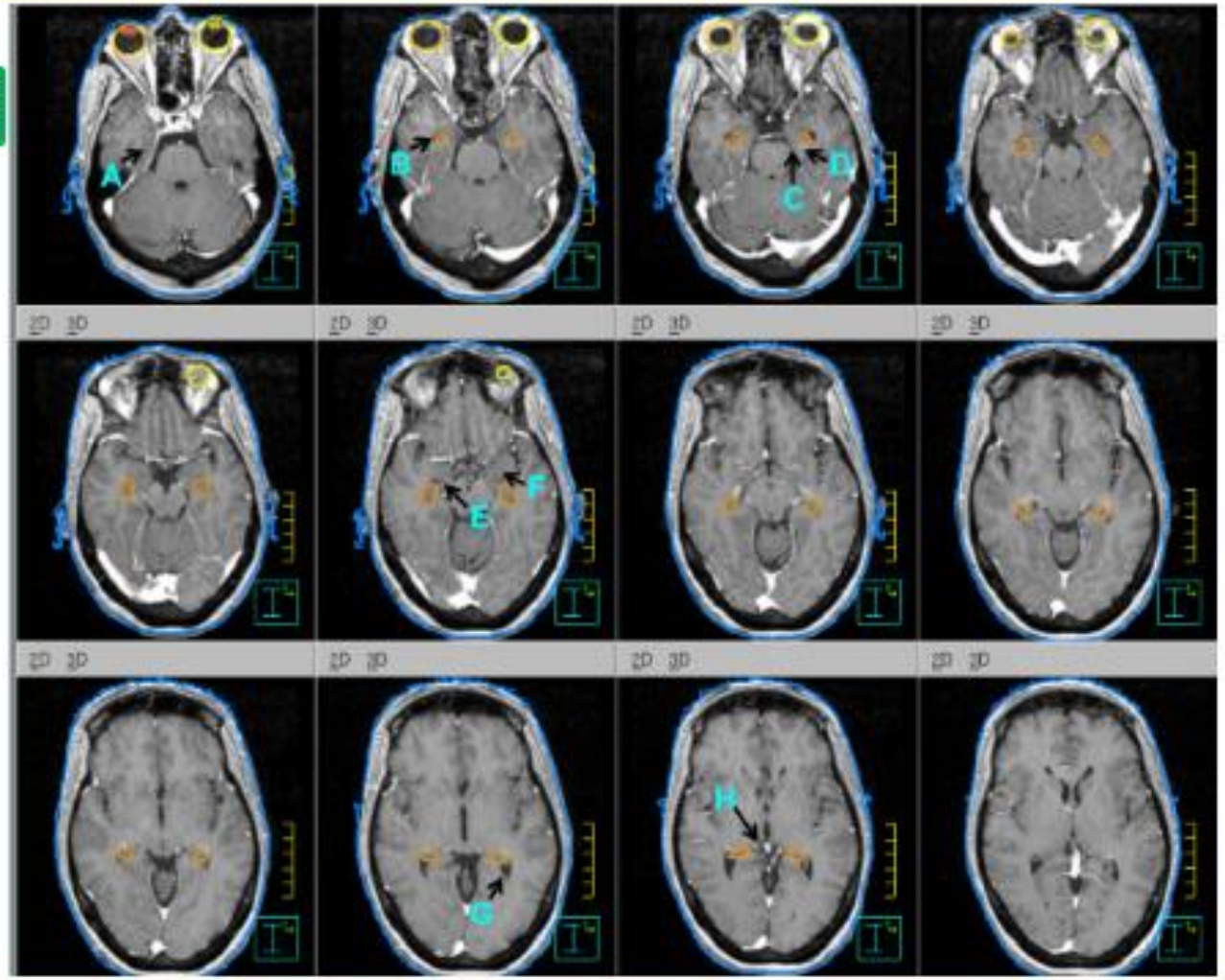
D)Fimbriae

E) Uncal recess

F)Amygdala

G)Atrium of the lateral ventricle

H) Lateral edges of the quadrageminal cisterns

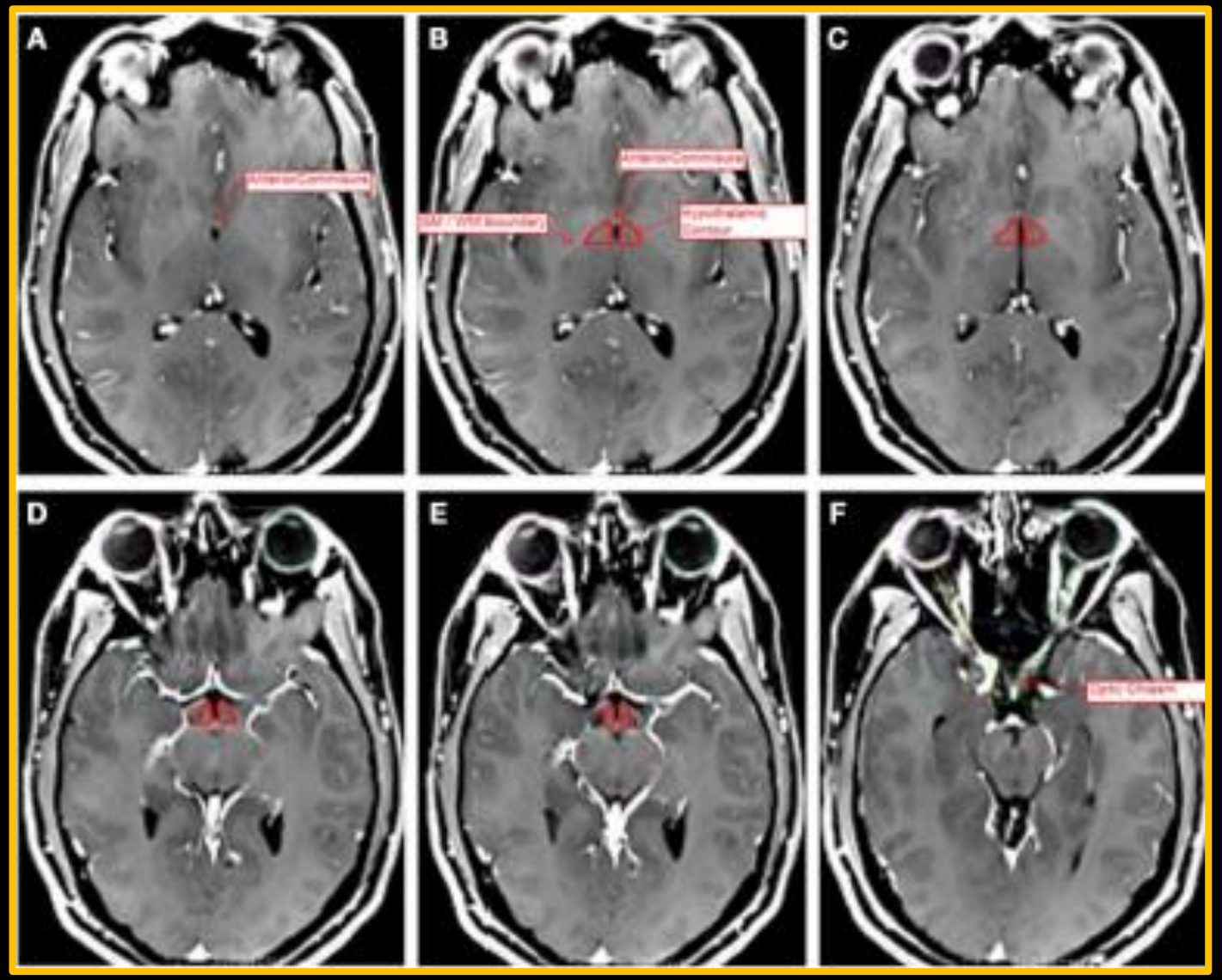


WBRT
Hippocampus
Max Dose: 16 Gy
D100% < 9 GY

T1 sequence , Hippocampal avoidance volume is 2 % of brain volume

Int J Radiat Oncol Biol Phys. 2010 November 15; 78(4): 1244–1252

Hypothalamus



Polygonal structure consisting of two separated volumes on each side of the 3rd ventricle or CSF space.
Sup- anterior commissure
Inf.- OC.
Ant.- ant. aspect of the 3rd ventricle or the visible edge of the CSF space within the suprasellar cistern.
Post- interpeduncular fossa.
Med.- 3rd ventricle or the visible CSF space
Lat.- optic white matter tracts or the internal capsule.

The dividing line between Infundibular stalk and hypothalamus is 3rd ventricle.

Try to keep hypothalamus mean dose <16 Gy to prevent GH deficiency

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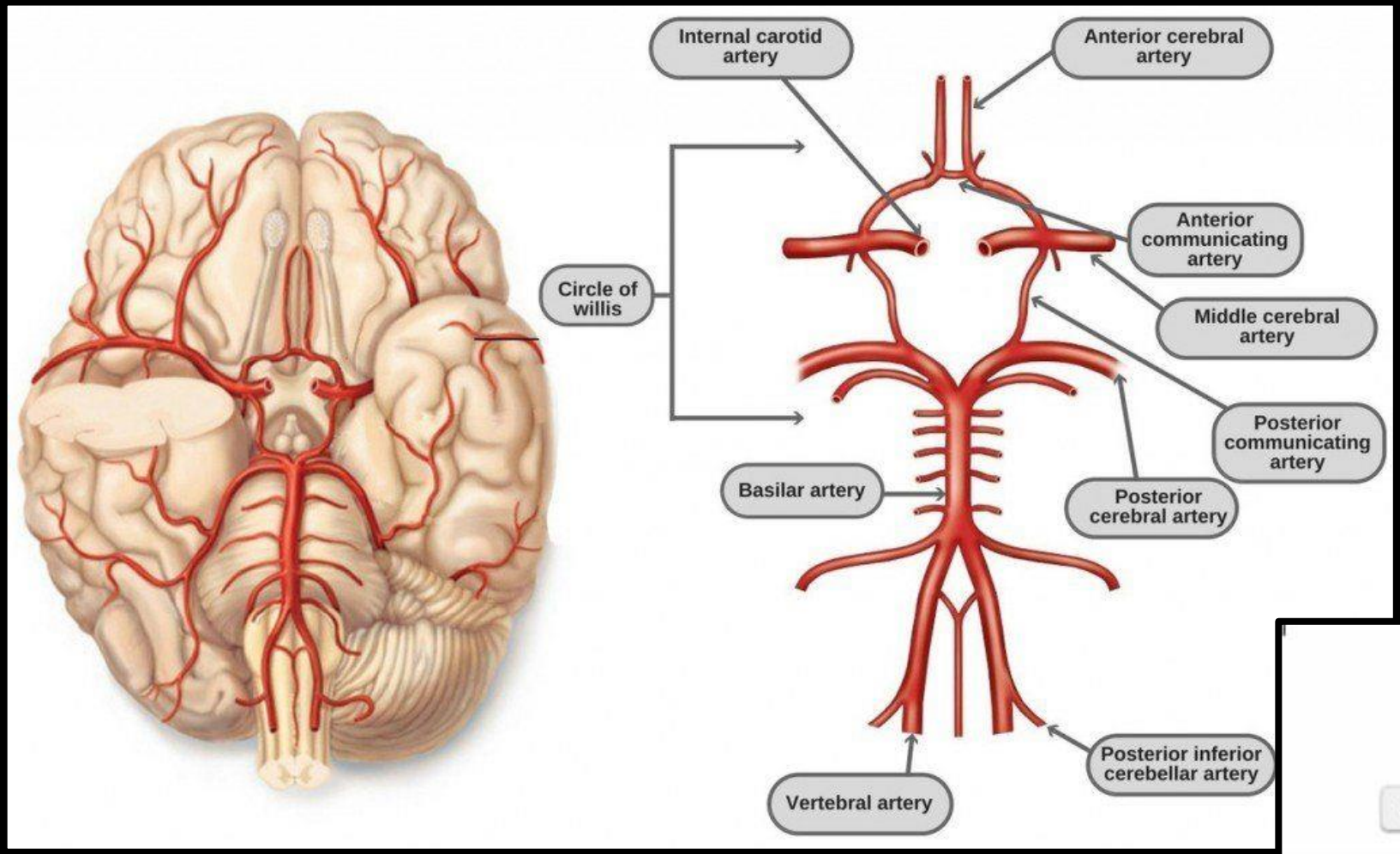
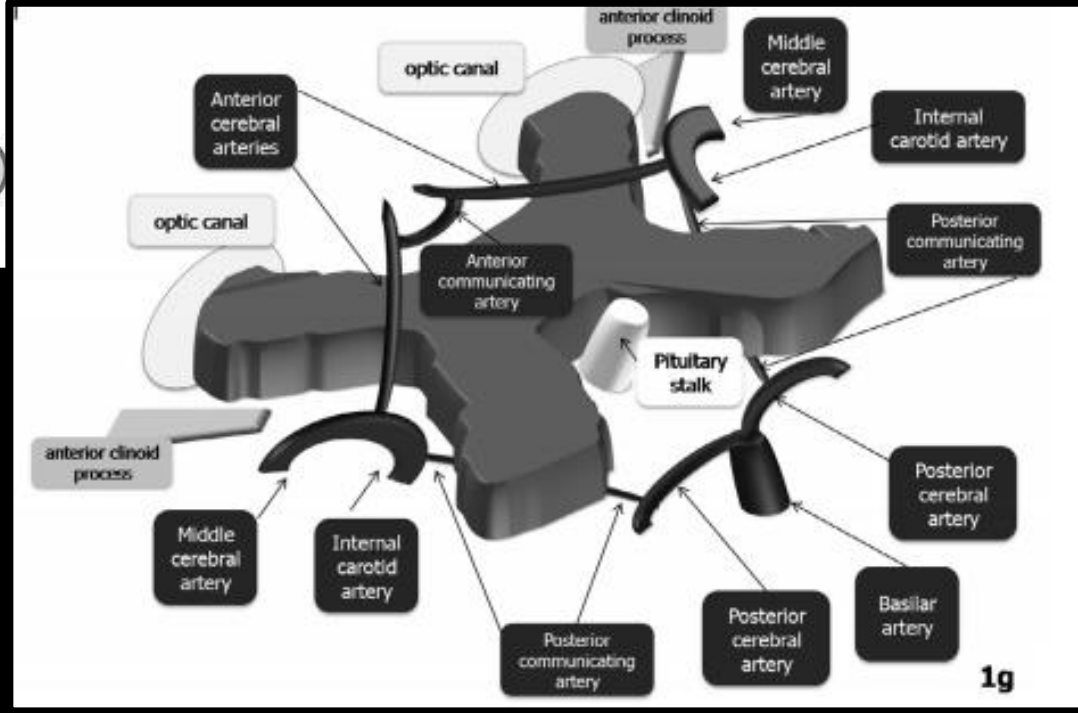
Circle of Willis





Relationship between optic chiasm and Circle of Willis

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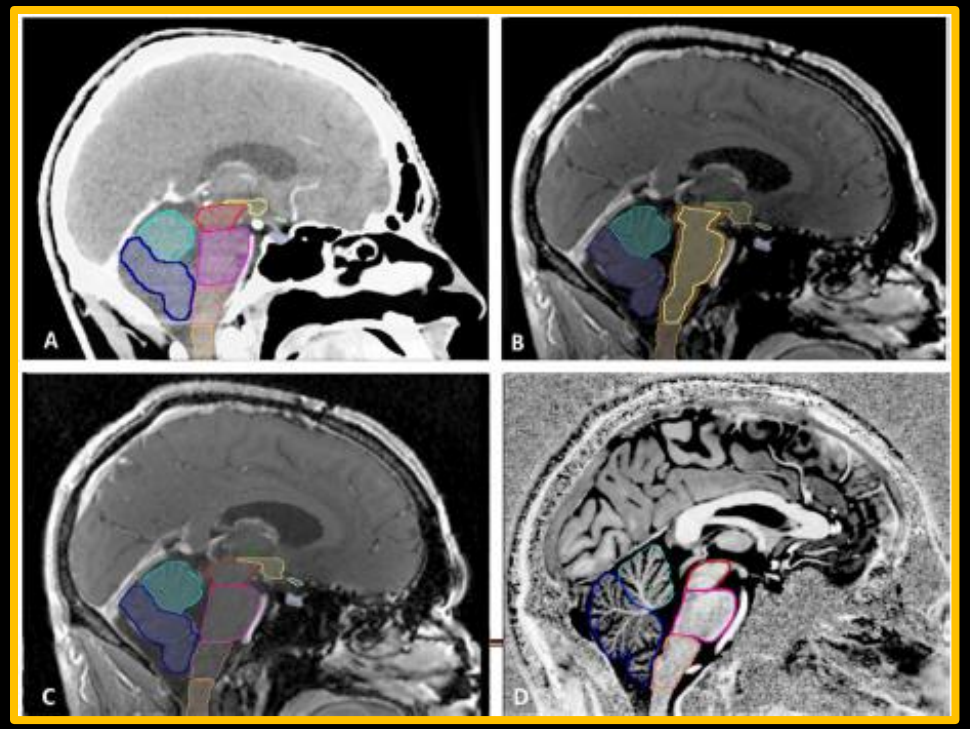
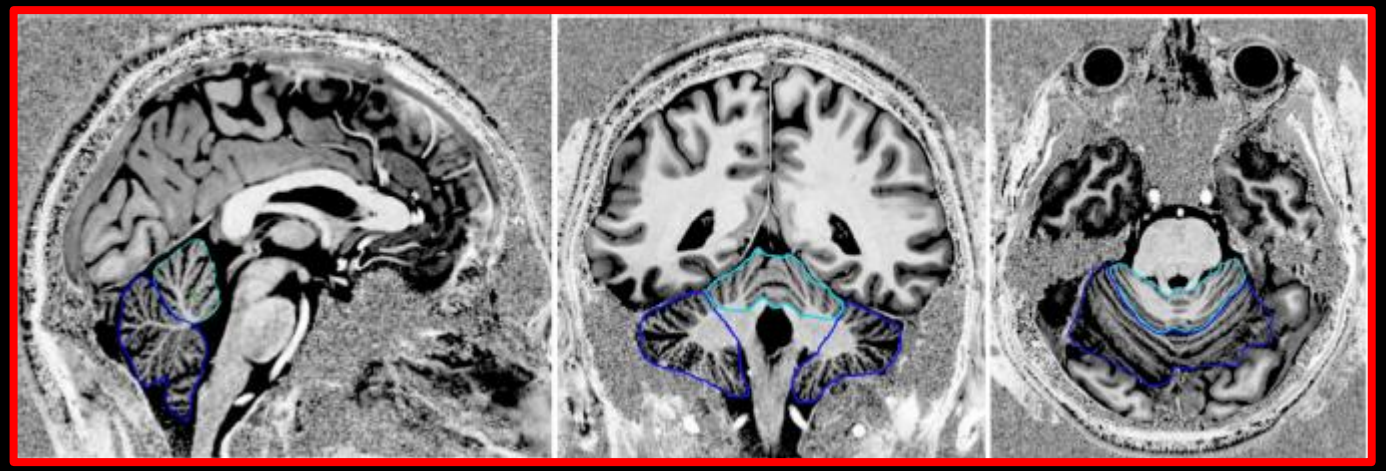
Editorial

The posterior cerebellum, a new organ at risk?

- The cerebellum consists of two hemispheres divided by the vermis. These are organized into ten lobules
- 3 anterior-posterior divisions
- the primary fissure separates the anterior lobe (lobules I–V) from the posterior lobe (lobules VI–IX)
- the posterolateral fissure separates the posterior lobe from the flocculonodular lobe (lobule X).





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Radiotherapy and Oncology 128 (2018) 37–43

Cognition, emotion and the cerebellum

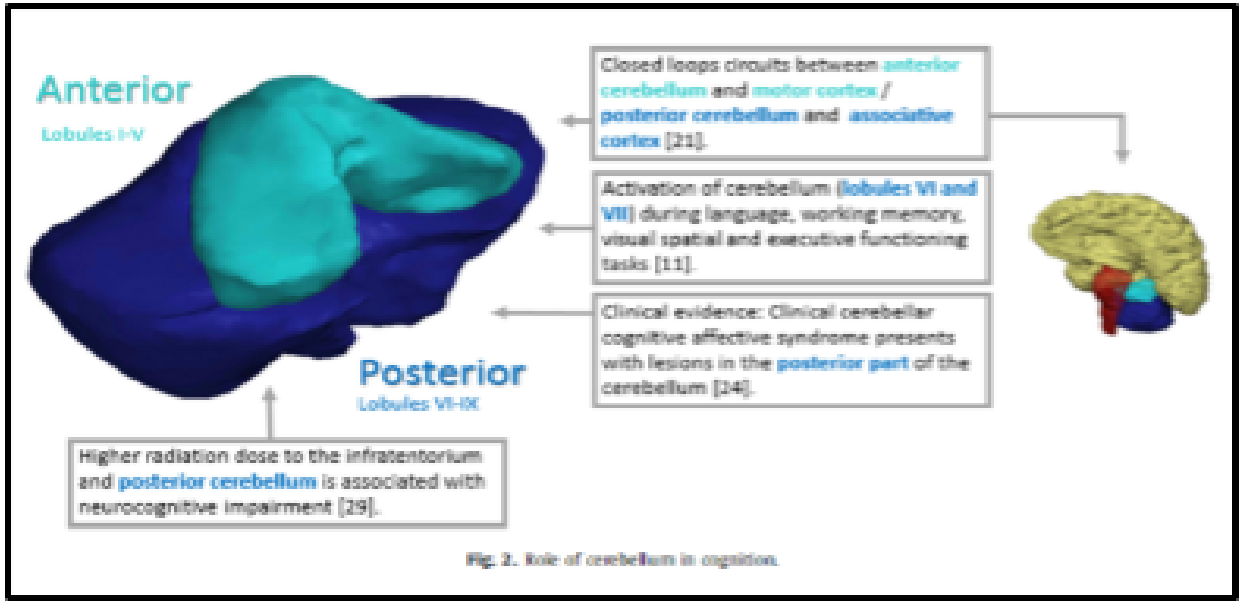

Fig. 2. Role of cerebellum in cognition.

Language-related activity -in lateral and posterior cerebellar regions
Working memory and reading tasks-activate B/l regions of the cerebellar posterior lobe mainly lobules VI and VII.
Functional imaging of affective processing, executive functioning and spatial processing highlights lobules VI and VII of the posterior cerebellar lobe.

Merchant et al- low grade glioma, showed post cerebellum associated with cognition
Gay et al- Head and neck pts.The patient with the lowest memory scores received a maximum dose **of 36 Gy on the cerebellum** and low radiation doses on the whole brain and hippocampi

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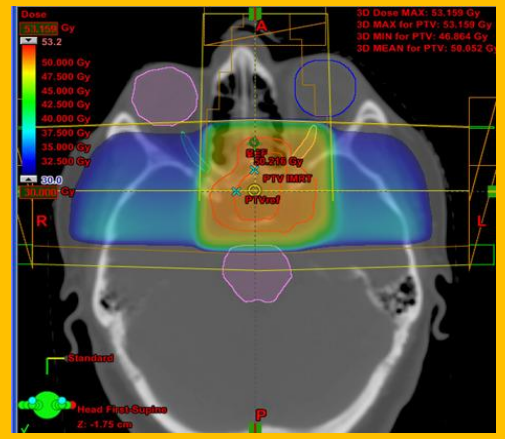
SchmahmannBrain (2006), 129, 288–292,

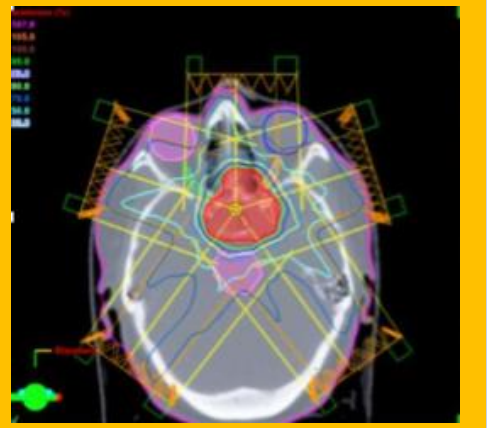
NeuroImage **10,** 233–260 (1999)

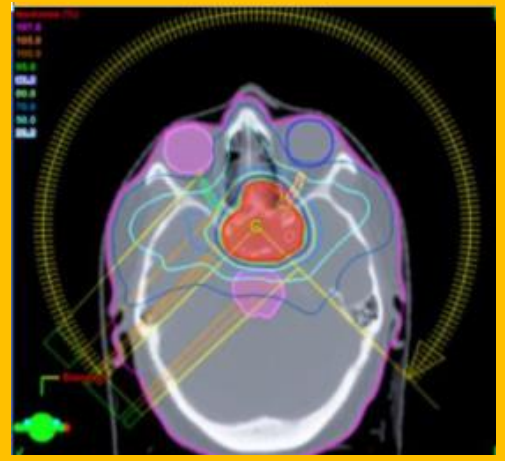
Radiotherapy and Oncology 128 (2018) 37–43

Beam arrangements/ Fields

- Mostly the clinician decides the delivery technique
- Medical Physics person decides the beam arrangements
- Beam arrangements may vary from simple single, opposed fields, IMRT fields, volumetric modulated arc plans or complex SBRT plans







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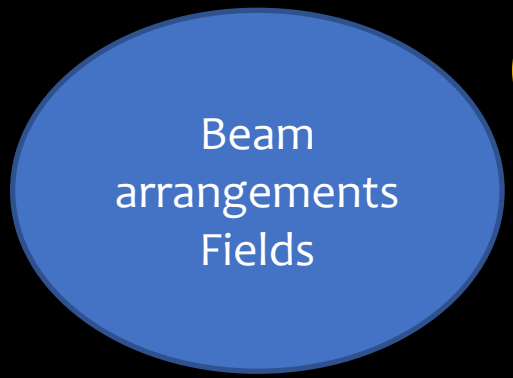
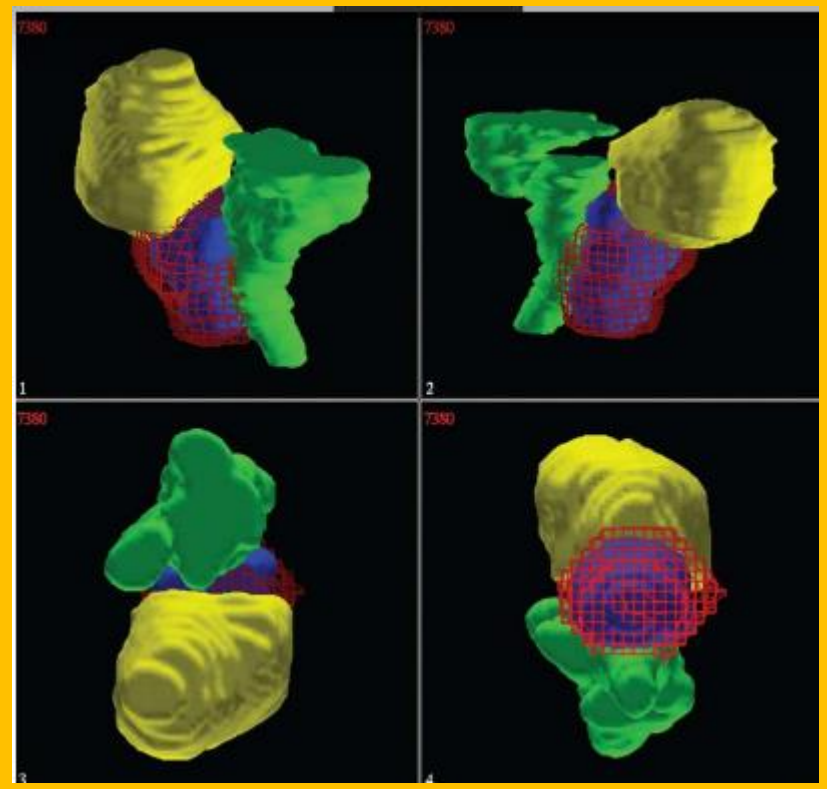


- Ensure that fields are entering the body at angles that avoid entry through excess normal tissue
- Ensure that beam shaping through multi-leaf collimators or other devices are appropriate for target and OAR
- Directly visualize each beam through beams eye view
- Can overlay isodose lines on CT images
- For IMRT check for number of beams and their point of entry & fluence patterns
- Try to minimize no of beams if palliative treatment & pt .unable to lie down for long times
- Check for number of arcs- full , partial and total treatment time

ROOM's view or 3 D view

- ✓ Rooms eye view is a 3D isodose surface display with real time interactivity.
- ✓ Tells about adequate coverage of target volumes and sparing of normal strs. with superimposed isodose surfaces or dose clouds from any viewing angle
- ✓ Hot or cold spots in areaof interest can be clearly seen.



Skin view- Beam aperture projection is clearly seen on skin of patient.

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Coverage

First ensure coverage qualitatively by review of structure and isodose contours on images

Ensure that prescription isodose line covers its corresponding PTV

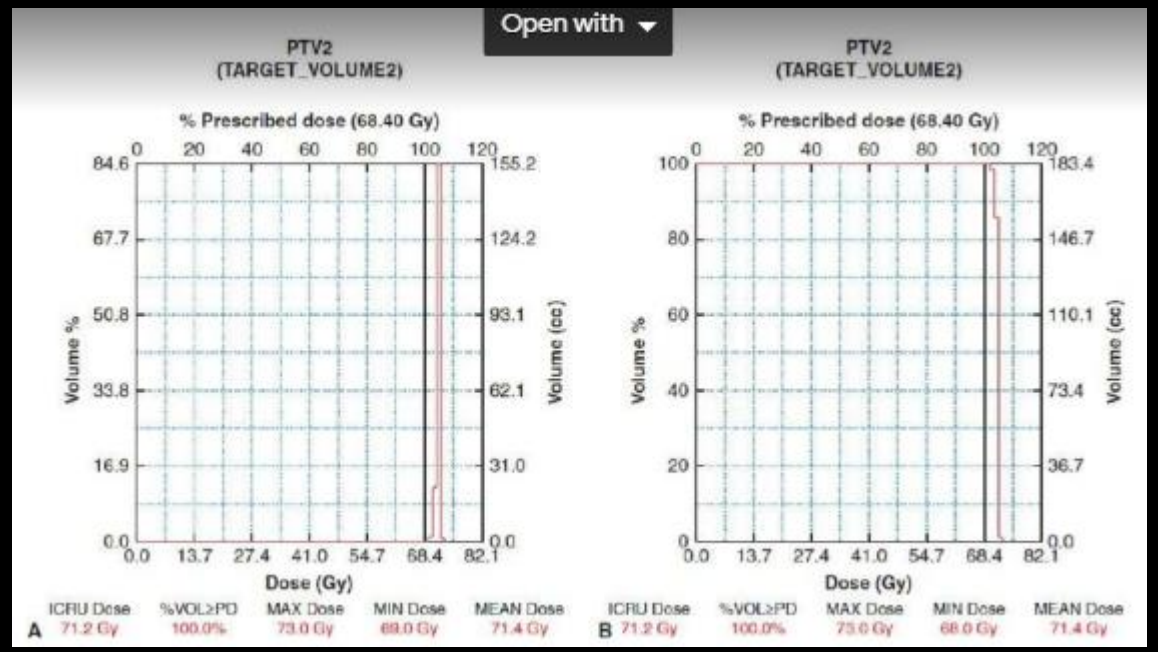
Identify inadequate coverage or excessive dose spillage outside the PTV

Check the DVH or dose volume histogram

Don’t forget to evaluate the 3D graphical plan qualitatively before proceeding to check DVH.

Usually coverage is considered adequate when at least 95% of PTV is treated to prescription dose or higher.

DVH



Differential DVH (dDVH)

PTV2- the volume is divided into individual elements called voxels and tagged according to dose received as determined from 3 D dose grid. Voxels ar then grouped according to each specified dose bin value without regard to their spatial location.
A plot of the number of voxels in each bin (y-axis) versus the bin dose range (x-axis) is a dDVH.

Cumulative DVH (c DVH)

Generated by summing for each dose bin for all the voxels of the PTV2 d DVH to the right of each dose bin. : the y-axis gives the volume, pr percentage of volume , that receives a dose equal to or greater than indicated dose on the x-axis.

QUANTEC: VISION PAPER

THE LESSONS OF QUANTEC: RECOMMENDATIONS FOR REPORTING AND GATHERING DATA ON DOSE–VOLUME DEPENDENCIES OF TREATMENT OUTCOME

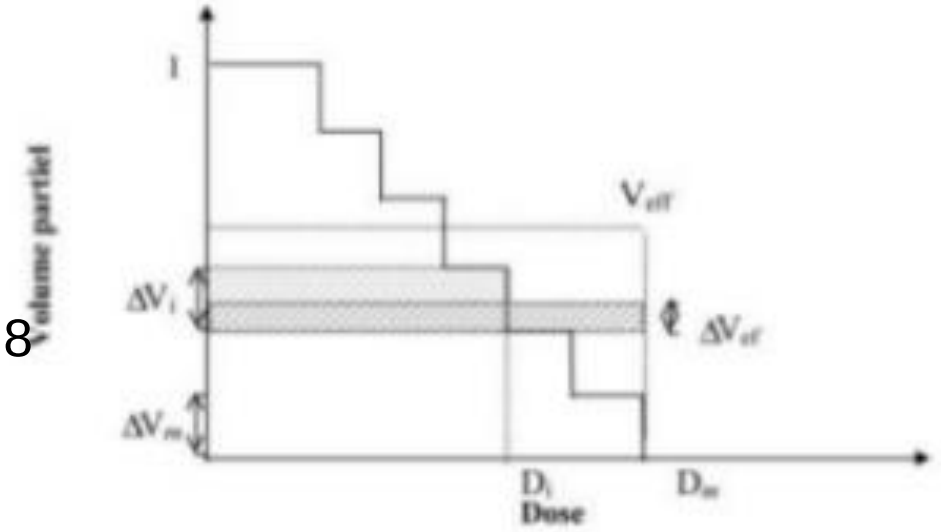
ANDREW JACKSON, PH.D.,* LAWRENCE B. MARKS, M.D.,† SØREN M. BENTZEN, PH.D., D.SC.,‡
AVRAHAM EISBRUCH, M.D.,§ ELLEN D. YORKE, PH.D.,* RANDAL K. TEN HAKEN, PH.D.,§
LOUIS S. CONSTINE, M.D.,† AND JOSEPH O. DEASY, PH.D.¶

……Dose–volume histograms including only partial volumes!!!!

NTCP

→Preferably, data used for NTCP analyses should include the full organ volume

→When this is not possible, either a standard method of normalization, or **absolute volumes** should be used



- ✓ Can’t assess the appropriateness of targets and OARS
- ✓ May report 100% coverage of PTV by the prescription dose but the PTV could be delineated incorrectly
- ✓ 95% coverage may not be met and there may be a compromise between PTV coverage and OAR constraints with an accepted sacrifice in PTV coverage to avoid unacceptable toxicity to surrounding critical OAR
- ✓ There may be excessive dose spillage through structures not reported within DVH
- ✓ Doe not provide information regarding spatial distribution of dose

Limitations of DVH

- no spatial information
  - where the hot / cold spot occurred
  - whether it occurred in one or several disconnected regions
- DVHs cannot be the sole criterion for evaluating / disclosing the best plan
- ***interpretation of the plot can be subjective!***

Heterogeneity

Means variability in dose distributions throughout the plan

- In conventional IMRT plan , acceptable minimum dose in PTV is around 95% with maximum around 115% of prescription dose.
- In 3 DCRT plan- heterogeneity is typically larger than for IMRT plans so greater variability is acceptable while care is taken to limit hot spots near critical OARS

GTV - Dark Red
CTV – Light Red
ITV – Dark Blue
PTV – Light Blue
OR – Dark Green
PRV – Light Green
Landmarks - Black

Acceptable dose heterogeneity :+7% to - 5% of the prescribed dose.

- Identify hot spots
- Cols spots
- Review the location of hot or cold spots within treatment plan
- Hot spot within GTV may be acceptable as opposed to in critical structures.
- A cold spot at edges of PTV is preferable to being within GTV or CTV.

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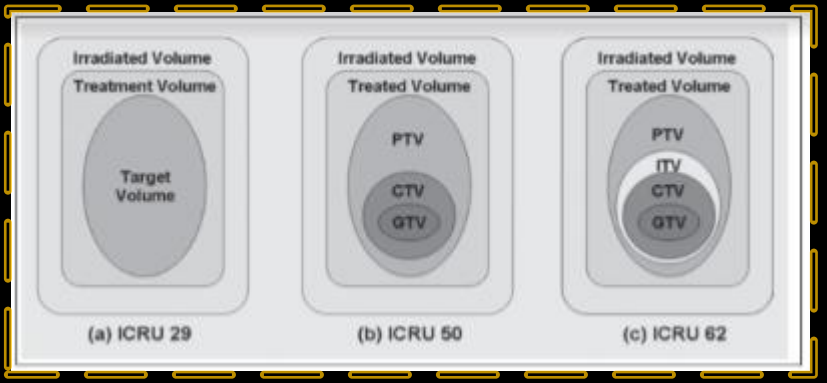
ICRU volumes



ICRU Report 29: 1970s–	ICRU Report 50: 1993–	ICRU Report 62: 1999–	ICRU Report 83: 2010–
1993	Present	Present	Present
Target volume	GTV CTV PTV	GTV CTV ITV PTV	GTV CTV ITV PTV
Treatment volume	Treated volume	Treated volume	Treated volume
Irradiated volume	Irradiated volume	Irradiated volume	Irradiated volume
Organ at risk	Organ at risk	Organ at risk	Organ at risk
		PRV	PRV
			RVR
Hot spot (area outside target that receives dose >100% of specified target dose; at least 2 cm^2 in a section)	Hot spot (volume outside PTV that receives dose >100% of specified PTV dose; >15 mm diameter)	Hot spot (volume outside PTV that receives dose >100% of specified PTV dose; 15 mm diameter)	High dose to RVR
Dose heterogeneity (no value given)	Dose heterogeneity (+7% to −5% of prescribed dose)	Dose heterogeneity (+7% to −5% of prescribed dose)	Not specified

CTV, clinical target volume; GTV, gross tumor volume; ITV, internal target volume; PRV, planning risk volume; PTV, planning target volume; RVR, remaining volume at risk.

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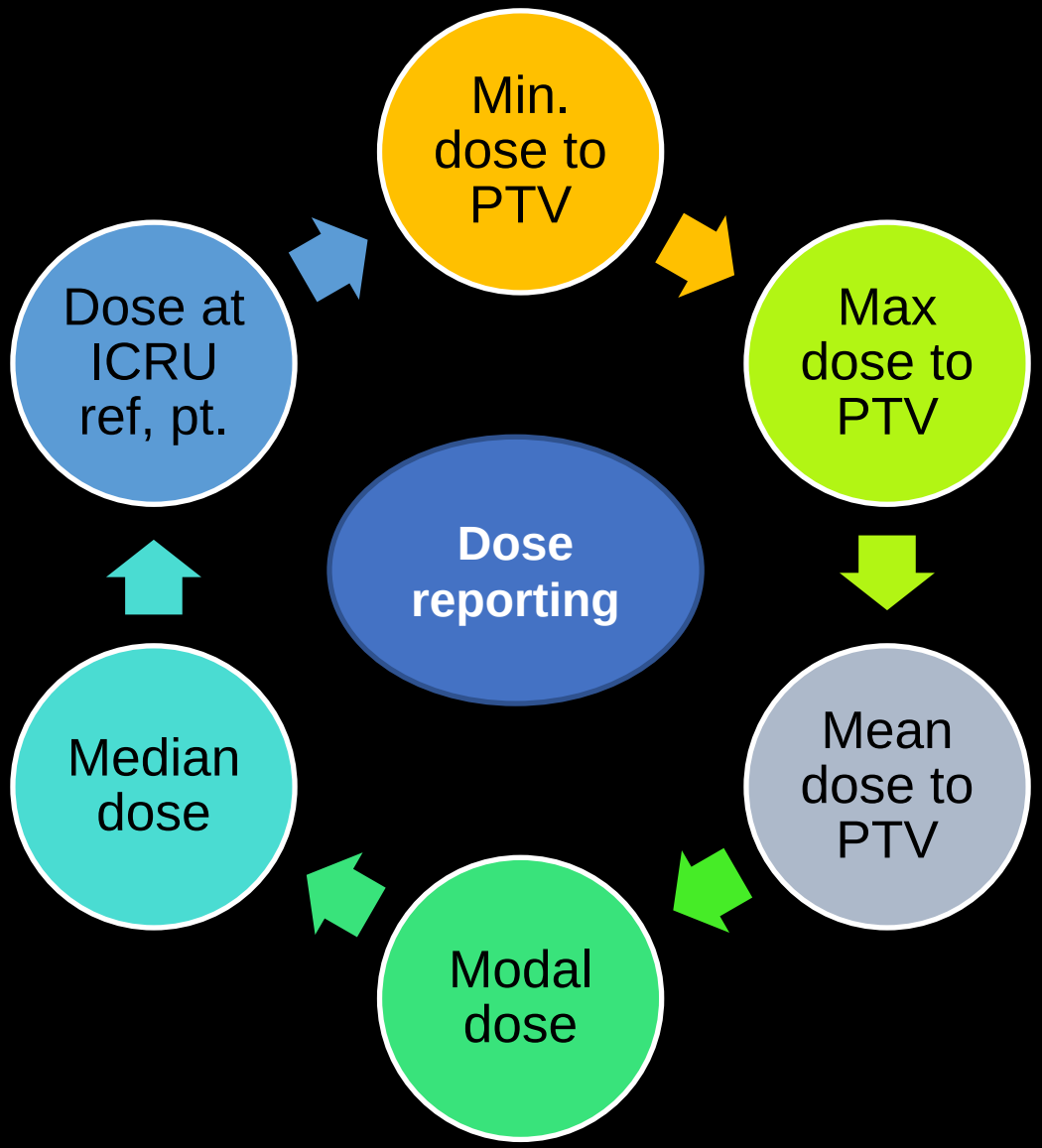


Dmax

- Max dose to PTV and OAR
- Helps in limiting dose and toxicity to OAR
- Reported only when a vol. of dia.>15mm is involved.
- Smaller volumes for eye, optic n. larynx
- If max outside PTV exceeds prescribed dose, then a hot spot can be identified.

Hot spots

- Volume outside PTV which receives dose >199% of prescribed dose
- Significant only if min dia >15mm
- But could be smaller in small organs as eye

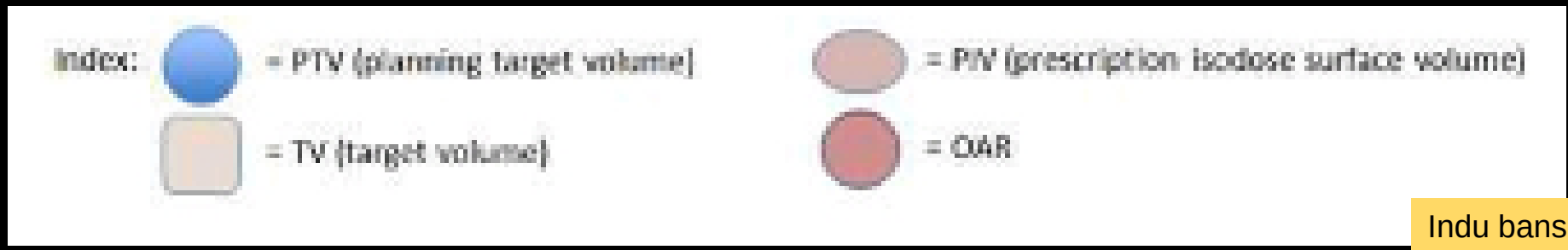
D min

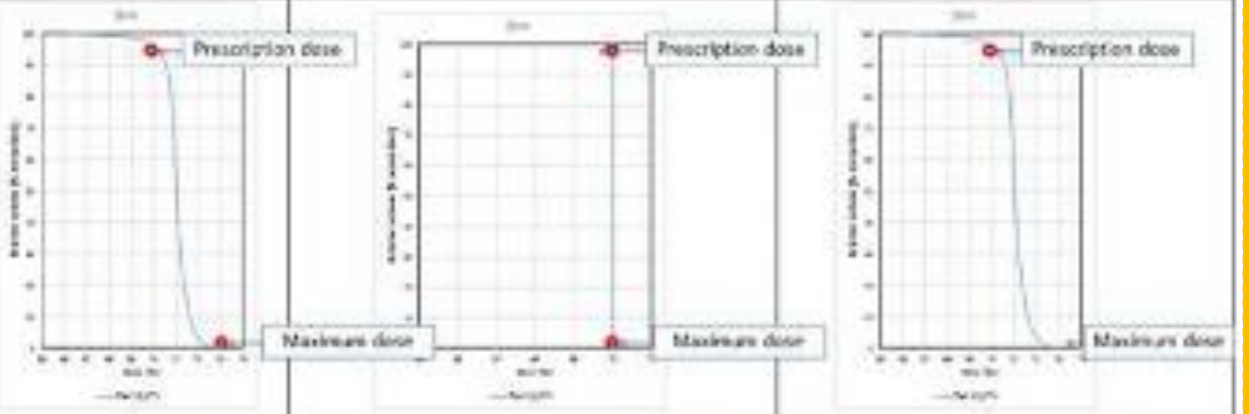
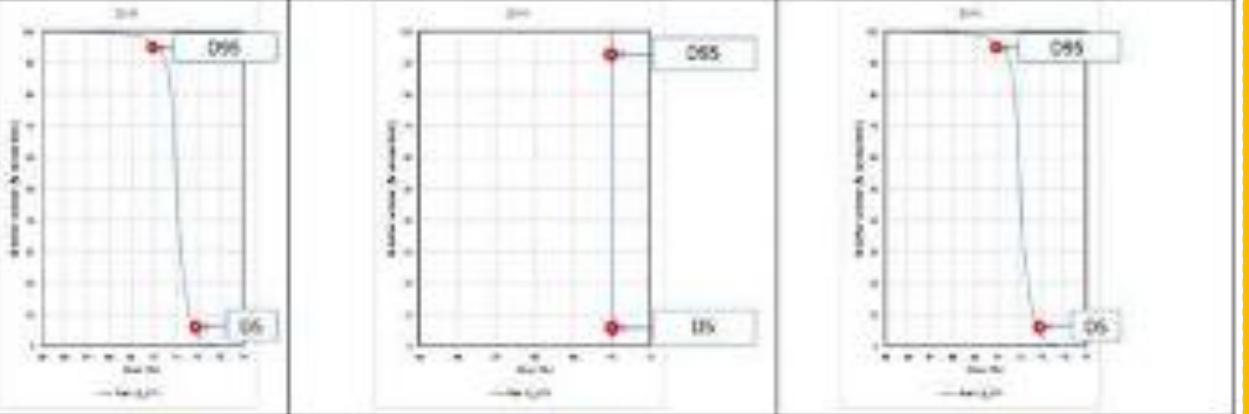
- Smallest dose in a defined volume
- No vol. limit defined for reporting

ICRU reference point

- The dose has to be clinically relevant
- The pt. should be easy to define in clear and unambiguous way
- The pt. should be selected so that dose could be adequately determined
- It should be in a region where there is no steep dose gradient .

Index	Formula	Concept	Value = 1	Value <1 or value >1
PITV (prescription isodose to target volume)	$PITV = \frac{PIV}{TV}$			
CI (conformity index)	$CI = \frac{PTV_{PD}}{PIV}$			
TCI (target coverage index)	$TCI = \frac{PTV_{PD}}{PTV}$			
CN (conformity number)	$CN = TCI \times CI = \frac{PTV_{PD}}{PTV} \times \frac{PTV_{PD}}{PIV}$			



HI (homogeneity index)	$HI = \frac{D_{max}}{PD}$			
MHI (modified homogeneity index)	$MHI = \frac{D_{95}}{D_s}$			
COSI (critical organ scoring index)	$COSI = 1 - \sum_i w_i \frac{V_i(OAR) \geq tol}{TC}$			

OARs

1. • Review both the DVH as well as 3 D graphic plan

2. • DVH tells max dose, mean dose and volume constraints

3. • Review the graphic plan to identify the location of critical isodose levels for each OAR and see the critical isodose line. It also helps to ensure that all OARS encompassed within these isodose lines have been contoured.

- Check the contours to see the overlap areas of OAR with PTV and decide priority of PTV over OAR

- Dose constraints may be used as given in QUANTEC for conventional fractionation.
- Check for proper BED conversions for both OARS and targets. .

- AAPM –TG -101 is a useful reference for hypofractionation. Some phase III protocols can also specify planning objectives and acceptable variations

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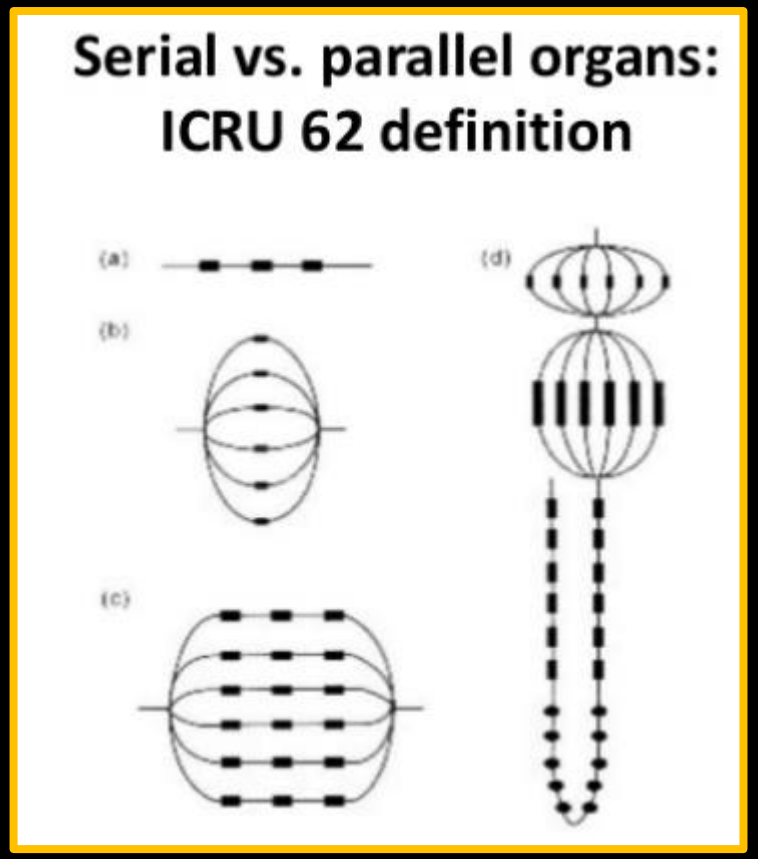
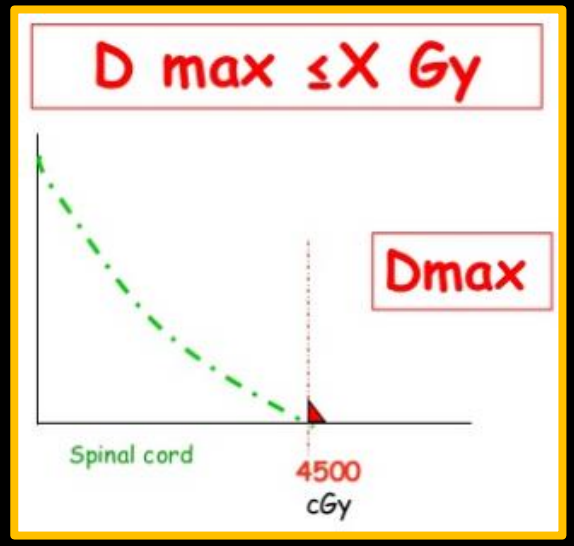
Serial



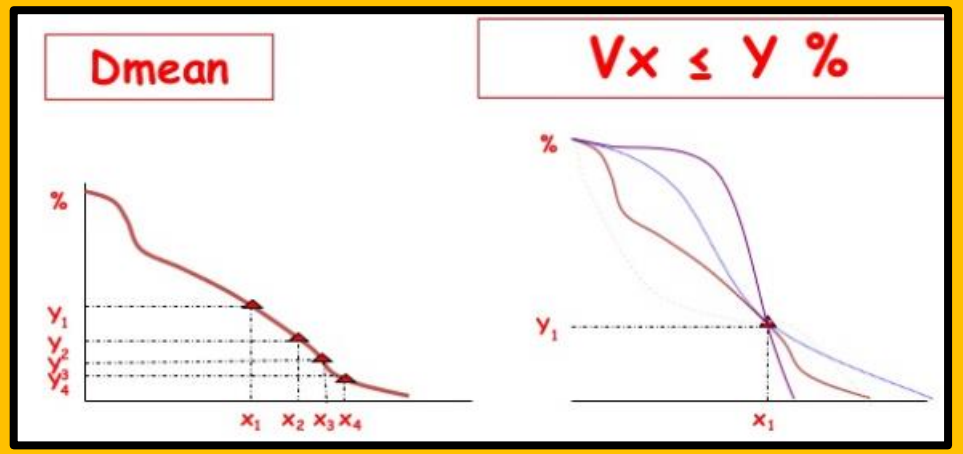


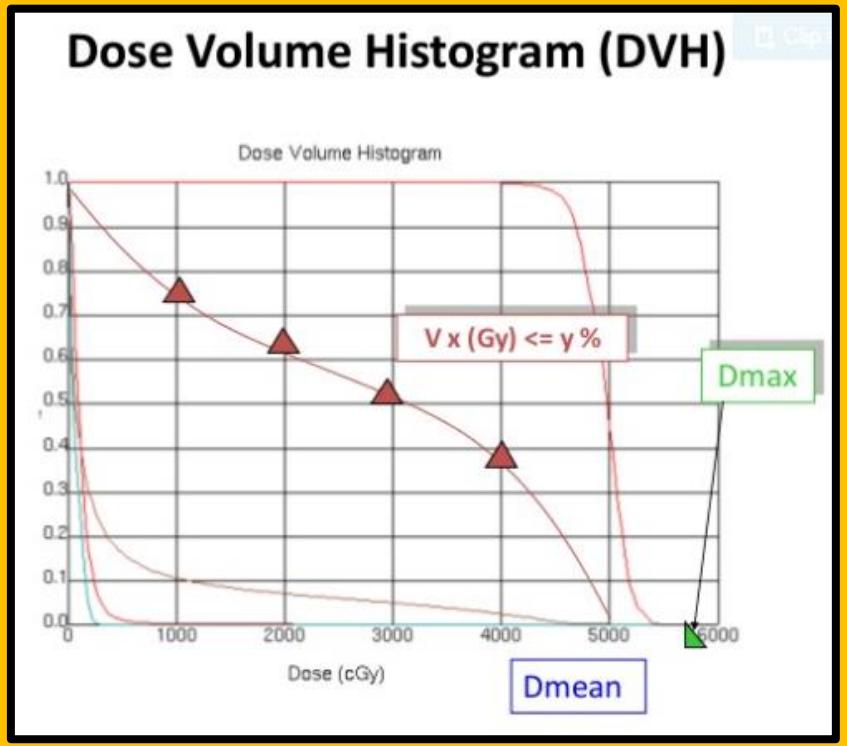
Serial- Damage at one point will cause complete damage of organ , e.g, cord, digestive e organs

Parallel- several FSU so if 1 part is damaged rest of organ will take over (lung, bladder)

Serial-parallel- Kidneys (glomerulus-parallel, tubules-serial), heart (myocardium-parallel, coronary a. serial)

Parallel





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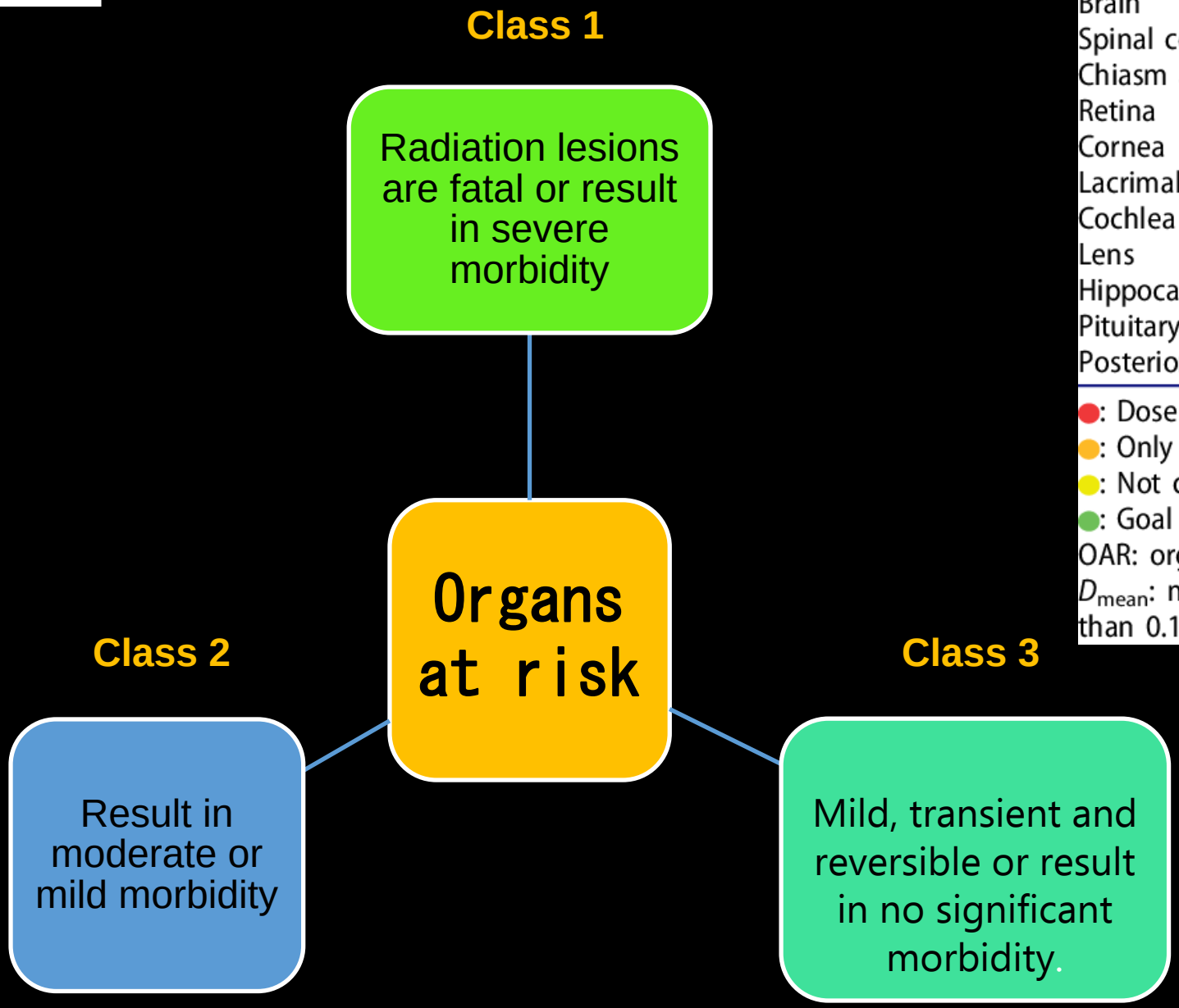

OAR	○	Tolerance	Priority
Brain stem	●	$D_{2\%}$ 54 Gy	1
Brain	●	$D_{2\%}$ 60 Gy	1
Spinal cord	●	$D_{2\%}$ 50 Gy	1
Chiasm and optic nerve	●	$D_{0.1cc}$ 55 Gy	1
Retina	●	$D_{0.1cc}$ 45 Gy	1
Cornea	●	$D_{0.1cc}$ 30 Gy	2
Lacrimal gland	●	D_{mean} 30 Gy	2
Cochlea	●	D_{mean} 45 Gy	3
Lens	●	$D_{0.1cc}$ 30 Gy	4
Hippocampus	●	D_{mean} 9 Gy	4
Pituitary gland	●	D_{mean} 45 Gy	4
Posterior cerebellum	●	D_{mean} ALARA	4

●: Dose limiting, exceeding this dose is not permitted.
●: Only dose limiting if the OAR was not part of the CTV.
●: Not dose limiting if the contralateral organ is preserved.
●: Goal limits, not dose limiting.
OAR: organ at risk; $D_{2\%}$: the maximum dose to 2% of the volume of the OAR; D_{mean}: mean dose; $D_{0.1cc}$ is the maximum dose reported in case 2% is smaller than 0.1 cc; ALARA: as low as reasonably achievable.

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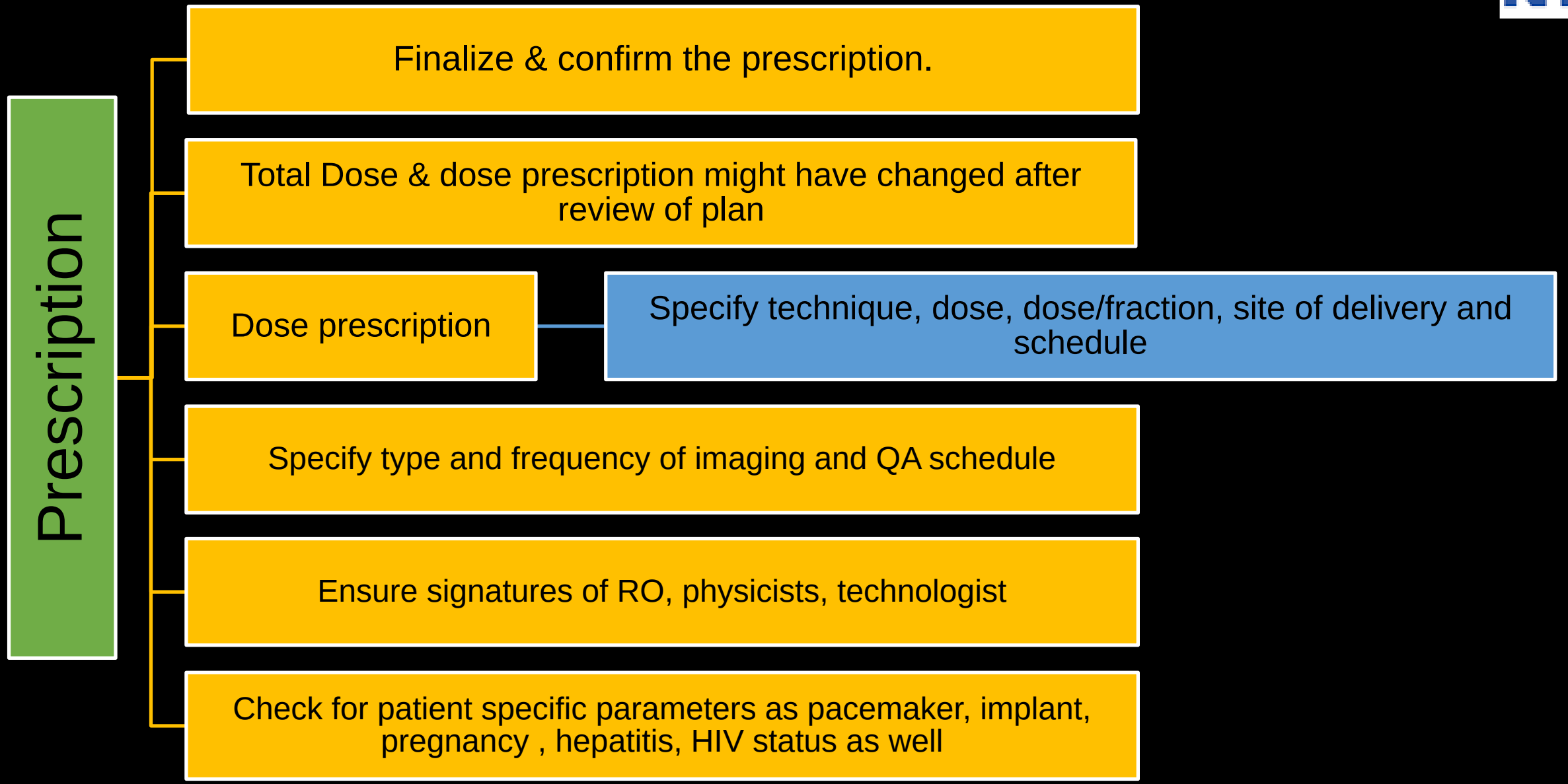

Prescription
Finalize & confirm the prescription.
Total Dose & dose prescription might have changed after review of plan
Dose prescription
Specify technique, dose, dose/fraction, site of delivery and schedule
Specify type and frequency of imaging and QA schedule
Ensure signatures of RO, physicists, technologist
Check for patient specific parameters as pacemaker, implant, pregnancy , hepatitis, HIV status as well

a/b ratios

TABLE 3.2 α/β Values

Early-Responding Tissues	α/β (Gy)	Late-Responding Tissues	α/β (Gy)
Skin (desquamation)	9.4–21.0	Spinal cord (paresis)	1.6–5
Skin—pig (desquamation)		—Cervical	2–3.4
—Time ≤16 d	8.7	—Lumbar	4–5
—Time >16 d	0.9	Brain (LD_{50}/10 mo)	2.1
Lip mucosa (desquamation)	7.9	Kidney (multiple endpoints)	0.4–5
Jejunal mucosa (clones)	7–13	Lung (pneumonitis)	1.6–4.5
Tongue mucosa (ulceration)	11.6	Lung (fibrosis)	2.3
Colonic mucosa (clones)	7–8.5	Heart failure	3.7
Hair follicles (epilation)		Liver (clones)	2.5
—Anagen	7.5	Bladder (frequency)	7.2
—Telogen	5.5	Bladder (contraction)	5.8–11.0
Testis (clones)	13.9	Bowel (stricture/perforation)	3.5–5
Spleen (clones)	8.9	Bowel (fistula/obstruction)	10.7
Bone marrow (clones)	9.0	Bowel (rectal stenosis, <5 d)	6.2
Melanocytes (depigmentation)	6.5	Bowel (rectal stenosis, >5 d)	1.1
Tumors (cure)		Dermal contraction	1.5–3.5
Experimental tumors	10–35	Dermal wound healing	2.5
Most human tumors	6–25	Eye cataracts	1.2
Human prostate cancer	1.5	Bone (human fracture)	2.2
		Cartilage and submucosa	1–4.9
		Total body irradiation (LD_{50}/1 y)	5.1

These values represent a synthesis from many sources. Individual values are means from one study. Where a range is given, it represents mean values from multiple studies.

RTOG data							QUANTEC data						Emami Data							Milano Data		
Critical Structure	Dose/ fx	Vol.	Dose	Max. Dose	Protocol	Treated organ	Critical Structure	Vol.	Dose/ Vol.	Max. Dose	Toxicity Rate	Toxicity Endpoint	Organ	TD 5/5			TD 50/5			Organ	Dose tolerance	Endpoint
Brachial Plexus	2 Gy	5%	60 Gy		619	Postop H&N	Brain			<60 Gy	<3%	Symptomatic necrosis		Whole	2/3	1/3	Whole	2/3	1/3			
	2 Gy			60 Gy	522	Definitive H&N				72 Gy	5%	Symptomatic necrosis	Brain	4500	5000	6000	6000	6500	7500			
	2 Gy			66 Gy	0619, 0617	Postop H&N, lung, nasopharynx				90 Gy	10%	Symptomatic necrosis										
	3 Gy			36 Gy	937	Lung							Brachial plexus	6000	6100	6200	7500	7600	7700			
	4 Gy			30 Gy	937	Lung																
Brainstem	1.8-2Gy	0.03cc		55 Gy (0.03 cc)	539	Intermediate risk meningioma				<54 Gy	<5%	Neuropathy or necrosis	Brain stem	5000	5300	6000	6500	–	–	Brain stem	V60 < 0.9 ml.	<5% grade >= 1 toxicity
	33 fxs			54 Gy	615	Nasopharynx	Brain stem	D1-10 cc	<= 59 Gy		<5%	Neuropathy or necrosis										
	1.8-2Gy			60 Gy (0.03 cc)	0539, 0825	High risk meningioma, glioblastoma				<54 Gy	<5%	Neuropathy or necrosis										
	2 Gy			57 Gy 0.03 cc	1016	Oropharynx																
Cochlea	33 fxs	5%	55 Gy		615	Nasopharynx	Cochlea	Mean	<=45 Gy		<30%	Sensory-neural hearing loss	Ear	5500	5500	5500	6500	6500	6500			
Larynx, glottis	Mean	20 Gy			1016	Oropharynx				<66 Gy	<20%	Vocal dysfunction	Larynx (necrosis)	7000	7000	7000	8000	8000	9000			
	2 Gy			45 Gy	0619, 0615	Postop H&N, definitive H&N, nasopharynx	Larynx	Mean	<50 Gy		<30%	Aspiration	Larynx (edema)	4500	4500	–	8000	–	–			
								Mean	<44 Gy		<20%	Edema										
								V50	<27%		<20%	Edema										

Radiation tolerances of OAR

Retina
Dmax <45-50Gy

Cornea
D0.03 cc 50 Gy

Lens
2 Gy- cataract
<6.5 Gy- 33% risk of progressive cataract at 8 years, 6.5 and 11.5 Gy- 66% risk of cataract progression at 4 years
Adults- Dmax 5-10Gy

Lacrimal gland
Dmean < 25 Gy
>40 Gy to lacrimal gland –dry eye
>57 Gy-permanent loss of tear secretion
100% rate of atrophy & fibrosis
Try to keep V30 less than 50%

Oral cavity- Dmean <40 Gy, < 1cc > 70 Gy

Scoccianti et al. / Radiotherapy and Oncology 114 (2015) 230–238, Arain 2015

Gonadal dysfunction
400 follicles released as oocyte during lifetime
<2 Gy- 50% immature oocytes destroyed
4-7 Gy- permanent ovarian failure
20 Gy- permanent ovarian failure
Early menopause at 31 yrs –CAD, bone loss
2-3 Gy- sperm production less
4-6 Gy- permanent azoospermia
12 Gy-increased LH
24 Gy to prepubertal testis- delayed puberty
33Gy- Leydig failure

Endocrine effects
< 1o Gy Total body RT - isolated GH deficiency
18–24 Gy cranial RT - Isolated GH deficiency
30 Gy -30-50% have the impairment of GH
>30 Gy -Gonadotrophin deficiency
>30 Gy-TSH and ACTH deficiency
>40 Gy-Precocious puberty
>40 Gy – Hyper-prolactinemia
>45 Gy- Hypothyroidism, thyroid nodule, grave

Organs at risk in the brain and their dose–constraints in adults and in children: A radiation oncologist's guide for delineation in everyday practice 2014

	Children	Adults	
Optic chiasm	Dmax < 54 Gy <60 Gy sec criterion	**D0.03 cc 55 Gy**	7% risk of optic neuropathy
Cochlea	Dmean < 35 Gy	Dmean < 45 Gy **Dmean 45 Gy** **Dmean 32 Gy**	
Hippocampus Hippocampal avoidance volume	D max < 6 Gy V3 Gy < 20% Dmax < 25.2 Gy and V20 Gy < 20% Dmax < 12 Gy V7.2 Gy < 40% Dmean < 30 Gy	**D40% 7.3 Gy** **Skin D 0.03 cc 25 Gy**	In WBRT 100% of the hippocampus should not exceed 9 Gy, Dmax<16 Gy in 10 Fractions.
Brainstem	Dmax < 54 Gy Dmax < 60 Gy D59 Gy < 10 cc	Surface D0.03 cc 60 Gy Interior D0.03 cc 54 Gy **Brain V60 Gy 1cc**	
Pituitary gland	Dmax < 50 Gy Dmean < 25 or 30 Gy	Dmax < 60 Gy Dmax < 42 Gy **Dmean 45 Gy, Dmean 20 Gy**	Ant pituitary- GH, TSH, gonadotropins, cortisol, prolactin
Retina		Dmax < 45 Gy Dmax < 50 Gy **D0.03 cc 45 Gy**	
Lacrimal gland		V30 Gy < 50% Dmax < 40 Gy, **Dmean 25 Gy**	
Lens		Dmax < 6 Gy Dmax < 10 Gy D0.03 cc 10 Gy	

Radiation dose constraints for organs at risk in neuro-oncology: the European Particle Therapy Network consensus 2018

Indu Bansal, NH, Gurugram

Table 2: Recommended/accepted re-irradiation normal tissue tolerances in late reacting tissues

Organ/tissue	Accepted re-irradiation dose-fractionated (Gy)	Accepted re-irradiation dose-stereotactic (Gy)	Accepted time interval between RT courses	Extent of OAR recovery
Soft tissue/ muscle	Doses over 50 Gy conventional EBRT produce better control[16,17]		>12 months	Large scale data not available; only case serie's present
Brain/ brainstem	Cumulative BED not exceed 130-159 Gy with an α/β ratio equal 2 Gy2[18]		>12 months	Partial
	30-40 Gy in fractionated RT[19]	24 Gy for involved volume <20 mm, 18 Gy for volume 21-30 mm and 15 Gy for volume 31-40 mm[8]		
Spinal Cord	cumulative BED should not exceed 130 Gy2[18]		>12 months	Partial
	20-24 Gy in10-12 fractions[13,14]	dose threshold for thecal sac 10 Gy in single fraction and nBED of 30-35 Gy 2/2 for up to five fractions		
Heart	Cumulative dose to the heart (BED_{Gy2}) should not exceed 70 Gy_3 and the point dose (0.1 cc) Dmax not >49 Gy_3[20]		>24 months	Partial
Great vessels	cumulative BED should not exceed 90-100 Gy2[21]		>36 months interval can produce estimated 65% OAR recovery[21]	1%-2% aortic toxicities noted; carotid blowout
Head and neck soft tissues	The dose ranges from 58-60 Gy[22]	18-40 Gy in 3-5 fractions to the 65%-85% isodose line over consecutive days[8]	>6 months-1 year	Lesser volume and more mucosa means more OAR recovery
Mandible	Cumulative dose not defined, but tolerance below 100 Gy_3 without cortical breach			
Parotid	Can tolerate cumulative dose of 45 Gy[23]		>12-18 months	
Optic structures	Re-irradiation constraints limited to <8-10 Gy for 10 cm^3 volume[24]		>12 months	
Urinary bladder	Can tolerate point cumulative doses of up to 120 Gy3[25]		>6 months-1 year	
Pelvic ureter	Can tolerate point cumulative doses of up to 110 Gy3[26]		>24 months	Ureteric stenosis
Rectal mucosa and wall	Total cumulative doses 70-100 Gy with a median total dose of 85 Gy[27,28]	IORT dose of 10-20 Gy[26,28]		Peripheral neuropathy most commonly seen with IORT
Femoral heads	Blood supply to the femoral head is defining point of action. Constraint similar to blood vessels; cumulative BED should not exceed 90-100 Gy2		>2-3 years gap can help recovery	Avascular necrosis of the head is the catastrophic event
Breast soft tissues	40-50 Gy given within 4 days with PDR brachy minimum re-radiation dose in fractionated schedule is 40 Gy		Minimum 6 months	Moderate skin and subcutaneous tissue side effects seen; mainly erythemas and skin telangiectasias
				Expected full OAR recovery

Indu bansal, NH, Gurugram

Das, et al.: OAR tolerance and recovery after re-irradiation

RE-Radiation tolerance

Spinal cord

Up to 39 Gy if at least 12 months between 2 RT

EQD2 -Dmax is 79 Gy
BED 3Gy - < 140 Gy3 .
D0.1cc < 71 Gy
D 0.5cc < 65 Gy
D 1.0 cc - 60 Gy

Cord tolerance appears to increase at least 25% at 6 months after the initial course of RT

SRS
Thecal sac 10 Gy ss
BED 30-35 Gy/5 F

Brain

Maranzano et al.
limit the dose to 60 Gy in each course of RT
Cumulative dose <140–150 Gy2

Mayer and Sminia
NTD cumulative-
< 81.6 Gy-101.9 Gy in conventional re RT
< 90 Gy-133.9 Gy in FSRT
< 111.6–137.2 Gy in SRS

Radio-necrosis
Not seen with conventional
FSRT –NTD cum >105 Gy
SRS- NTD cum >135 GY

SRS- 24 Gy for involved volume < 2mm
18 Gy for 21-30mm
15 Gy for 31-40mm

Indu bansal, NH, Gurugram

Pacemaker

- ✓ Check the patient's coronary and pacemaker status evaluated by a cardiologist before and soon after completion of therapy.
- ✓ Always keep pacemaker outside machine collimated RT beam both during RX & during portal films
- ✓ Check for any malfunctions happening during Rx
- ✓ Before Rx, estimate and record the dose from scatter to be recd. by the pacemaker.
- ✓ If patient has an automatic cardio-inverter fibrillator (AICD), follow same steps as for pacemaker. If no manufacturer instructions available, conservative threshold of 100cGy to be considered.

The total accumulated dose for pacemaker should be < 2 Gy

IF AICD follow manufacturer instructions or keep threshold below 100cGY.

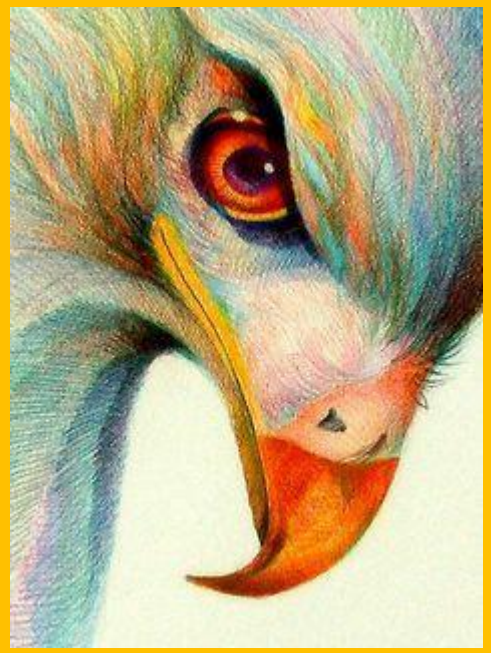
Marbach 1994 AAPM task group no 34.

How to keep fetal dose low?

- Complete all planning as if pt. not pregnant,
- Consider modifications of plan to minimize dose to fetus e.g. changing field size and angle, using a different energy, Avoid Co60 or >10 MV because of neutrons. Use tertiary collimation to define field edges nearest to fetus
- Estimate dose to fetus without shielding using AAPM report using phantom.
- Design and construct special shielding , 4-5HVL lead sufficient. It must allow Rx fields above diaphragm and on lower extremities. Commonly used shielding arrangements are bridge over patient, table over treatment couch and midline shield.
- Document treatment plan and inform all personnel involved with care.
- Check all aspects of safety, prevention of falls, to ensure safety to patient and personnel. Clicks photographs.
- Monitor fetal size and location throughout course of RT and update estimates of dose when necessary.
- Document completion of treatment by estimating the total dose to the fetus

Stovall Fetal dose from RT, AAPM task group 36

Develop an eagle’s eye



Thank you