Concepts of Plan evaluation in SRS / SRT

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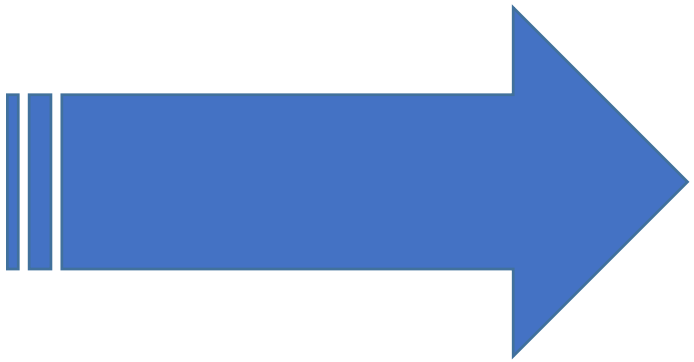
Outline of the Presentation

- Introduction to SRS
- Brief History
- Radiobiological principles of SRS
- Workflow
- Different delivery systems of SRS
- Concept of Plan Evaluation
- Quality Assurance



BRIEF HISTORY OF RADIOSURGERY

DR LARS LEKSELL

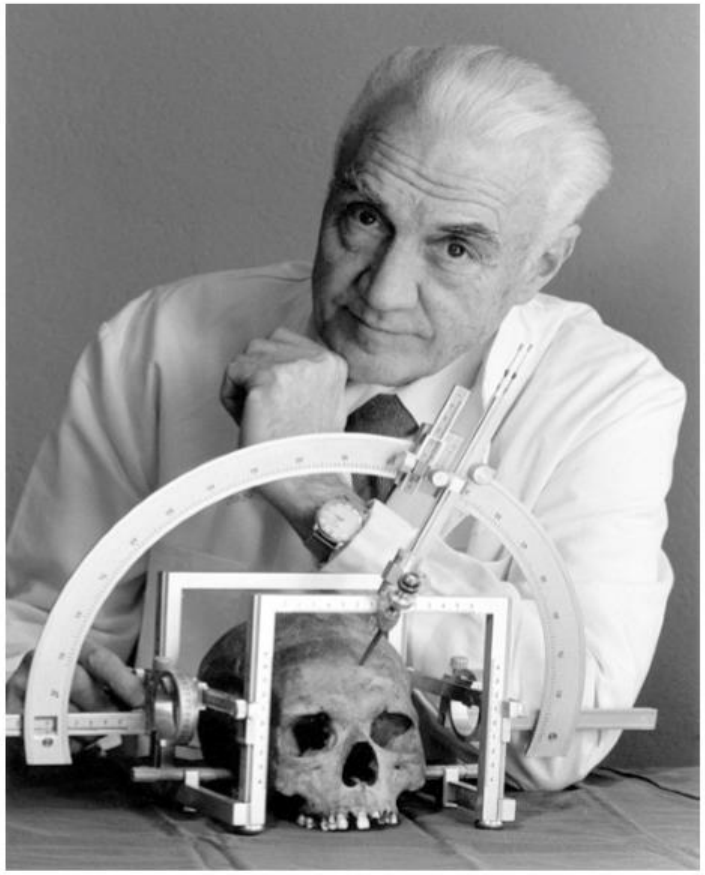


Fig. 2 Swedish neurosurgeon Lars Leksell with his stereotactic frame. (Used with permission of Elekta Instrument, Stockholm, Sweden)

- Termed “stereotactic radiosurgery”- 1951
- Used orthovoltage to treat **Trigeminal neuralgia**
- Leksell+ **Borge Larsson**- 1st SRS Gamma unit using 179 Cobalt 60 was installed at Sophiahemmet Hospital in 1968
- 2nd at Karolinska Hospital Stockholm in 1974

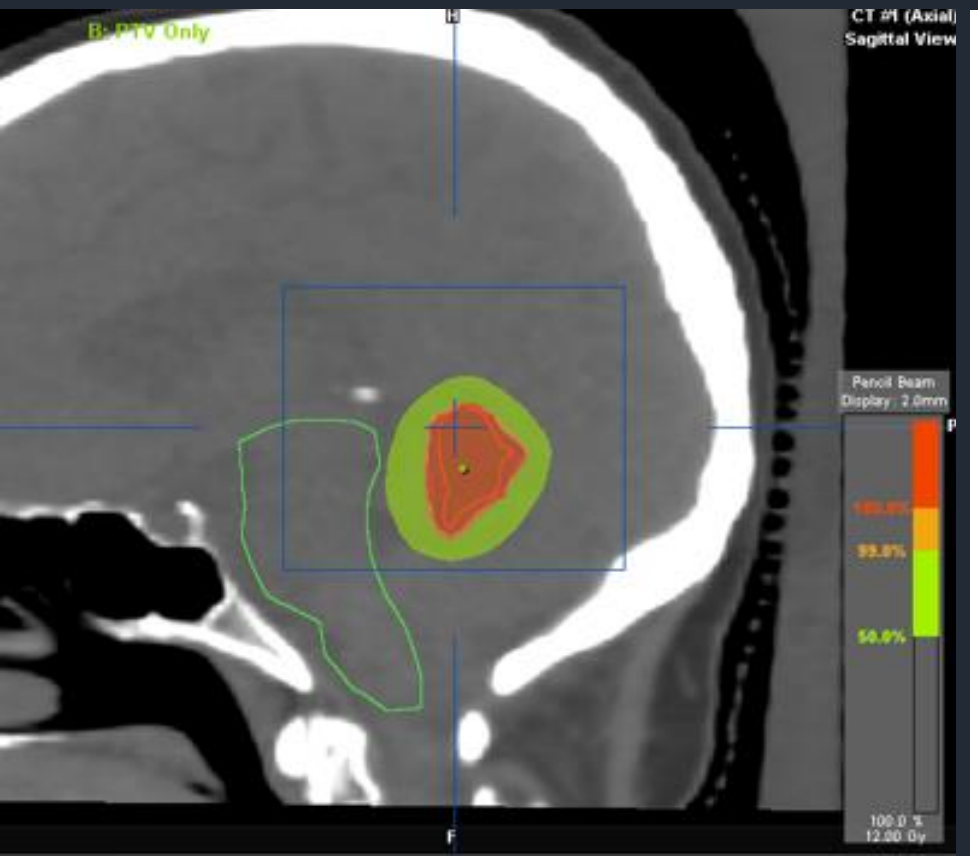
- Megavoltage x ray beams from isocentric linacs are used in radiosurgery since the mid 1980s.
- **Ernest Spiegel and Henry Wycis** created a stereotactic frame for human patients

Characteristics of SRS

Journal Of NeuroSurgery 2007

Stereotactic radiosurgery—an organized neurosurgery-sanctioned definition

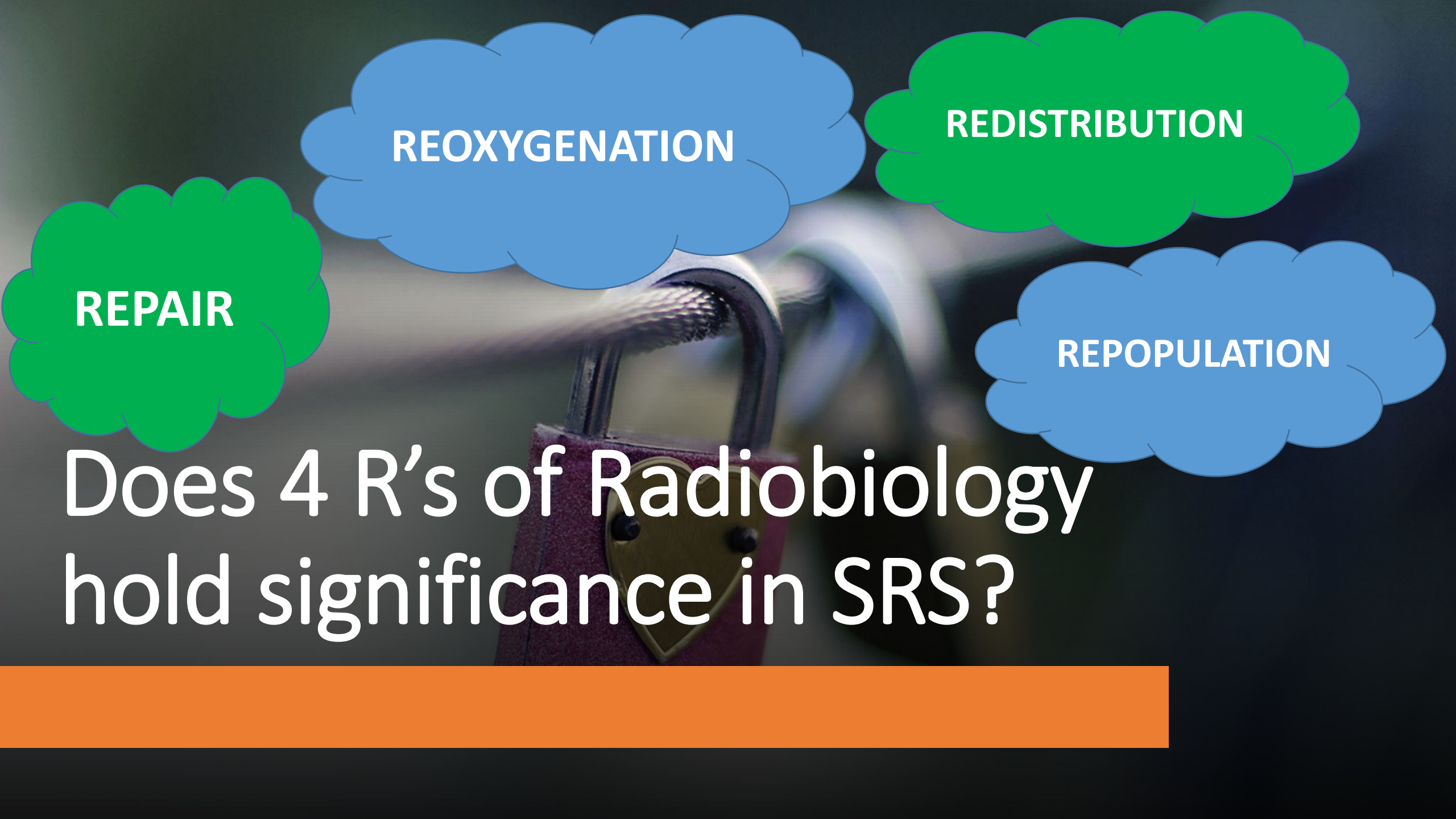
GENE H. BARNETT, M.D.,[1] MARK E. LINSKEY, M.D.,[2] JOHN R. ADLER, M.D.,[3] JEFFREY W. COZZENS, M.D.,[4] WILLIAM A. FRIEDMAN, M.D.,[5] M. PETER HEILBRUN, M.D.,[6] L. DADE LUNSFORD, M.D.,[7] MICHAEL SCHULDER, M.D.,[8] AND ANDREW E. SLOAN, M.D.,[9] THE AMERICAN ASSOCIATION OF NEUROLOGICAL SURGEONS/CONGRESS OF NEUROLOGICAL SURGEONS WASHINGTON COMMITTEE STEREOTACTIC RADIOSURGERY TASK FORCE



- Highly conformal and High Precision
- High Accuracy- Positional (+/- 1mm)
- Focal irradiation- Lesion size </= 3cm
- Ablative doses : 12-24Gy margin dose
- Single Fraction (MF ➔SRT)
- Intracranial +/- Spine
- Minimally-invasive (Gamma knife)
- Multiple, converging beams
- Rapid dose fall off at the edge of target

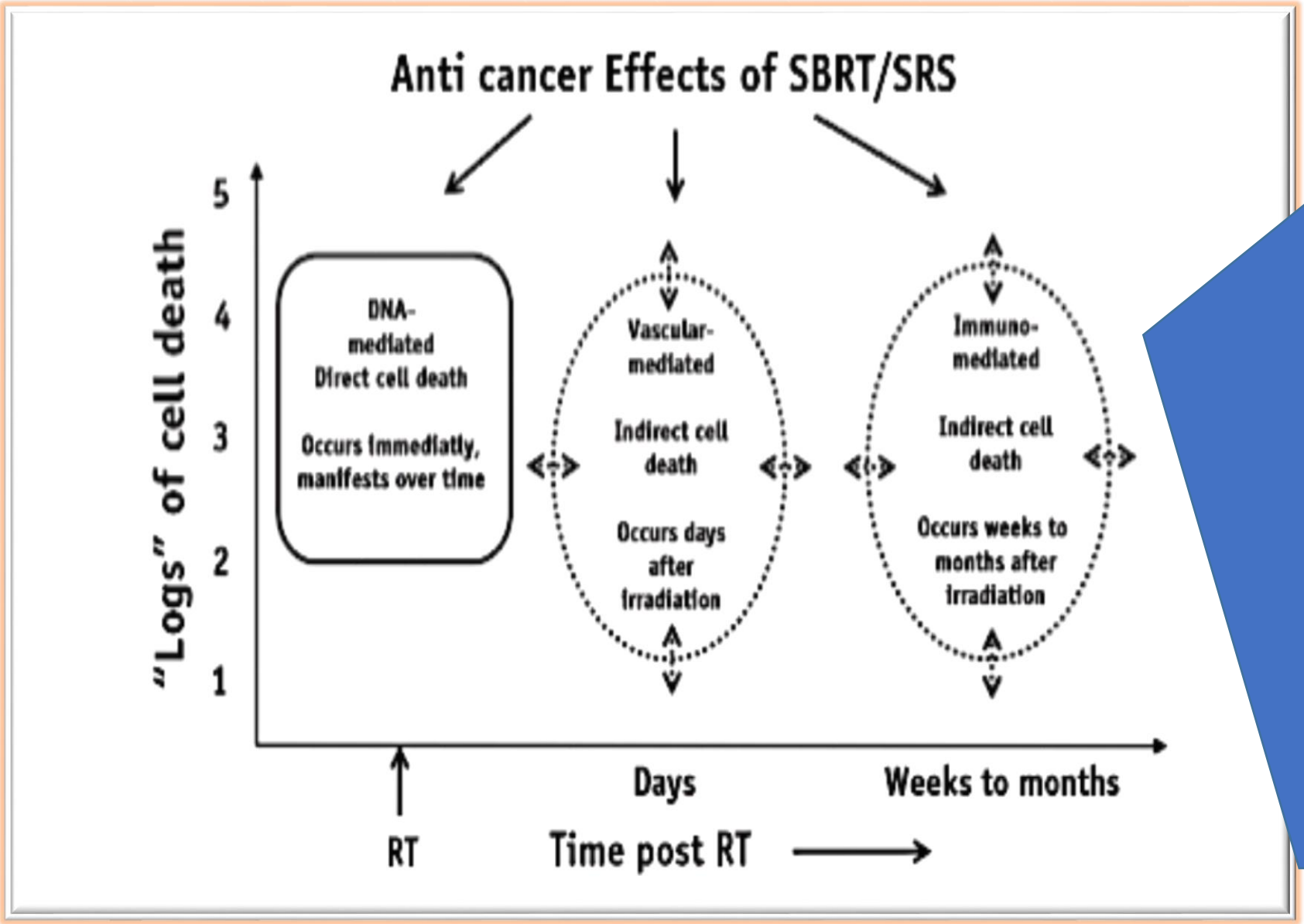
Indications of SRS

- Vascular lesions: **AVM, Acoustic neuroma**
- Functional disorders: **Trigeminal neuralgia, Parkinson's disease, Intractable Epilepsy**
- Primary benign tumours: **Pituitary adenoma, Meningioma**
- Primary malignant tumours: **GBM, Pineal tumour**
- Metastatic tumours: ***SRS alone**
  ***WBRT f/b SRS**
  ***SRS f/b WBRT**
  ***fSRS / SRT**
  ***Re-RT setting**



Does 4 R's of Radiobiology hold significance in SRS?

Radiobiology of SRS



- Endothelial Cell Apoptosis Theory
- Vascular Damage
- Anti-tumour Immunity & Abscopal Effect

International Journal of Radiation Oncology biology • physics

www.redjournal.org

Critical Review 2014

The Tumor Radiobiology of SRS and SBRT: Are More Than the 5 Rs Involved?

J. Martin Brown, PhD,* David J. Carlson, PhD,† and David J. Brenner, PhD‡

**Department of Radiation Oncology, Stanford University School of Medicine, Stanford, California; †Department of Therapeutic Radiology, Yale University School of Medicine, New Haven, Connecticut, and ‡Center for Radiological Research, Columbia University Medical Center, New York, New York*

"We conclude that the available preclinical and clinical data do not support a need to change the LQ model or to invoke phenomena over and above the classic 5 Rs"

"Excellent results obtained from clinical studies are the result of the much larger BED that are delivered with SRS"

Invasive

- **Painful: Patient head is fitted with a localizer frame**
- **Same day t/t:**
  Can not be protracted

Non Invasive

- **Painless-May be claustrophobic**
- **Can be protracted over time & fractions**

Gamma Knife

- Both Farmless and invasive frame is possible
- Nonuniform dose distribution-Dose prescription (50%)-

LINAC

- Both Farmless and invasive frame is possible
- Uniform or non uniform Dose distribution-Prescription is at 80% or volumetric

Gamma Knife

Both Farmless and invasive frame is possible

We will restrict our discussion on dose evaluation in the LINAC based Stereotaxy:
GK has limited application.

Radiotherapy and Oncology 147 (2020) 136–143

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Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

2020

Original Article

Linear accelerator-based radiosurgery is associated with lower incidence of radionecrosis compared with gamma knife for treatment of multiple brain metastases

Nikhil T. Sebastian [a], Chase Glenn [b], Ryan Hughes [b], Raju Raval [a], Jacqueline Chu [a], Dominic DiCostanzo [a],

Stereotactic Devices and Characteristics

	Intracranial	Extracranial	Motion Management	Arc Therapy	Multifraction	Adaptive	Cone-Beam CT
Cyberknife	Yes	Yes	Yes	No	Yes	No	No
Gamma Knife	Yes	No[a]	No	No	Yes[b]	No	Yes[b]
Infinity	Yes	Yes	Yes	Yes	Yes	No	Yes
Novalis	Yes	Yes	Yes	Yes	Yes	No	Yes
Protons	Yes	Yes	No	Yes	Yes	No	No
TrueBeam/ Trilogy	Yes	Yes	Yes	Yes	Yes	No	Yes
Tomotherapy	Yes	Yes	No	Yes	Yes	Yes	Yes

[a]Can treat upper cervical spine.
[b]Gamma Knife Icon only.

Flowchart of a typical course of Radiotherapy

PRE RT WORKUP

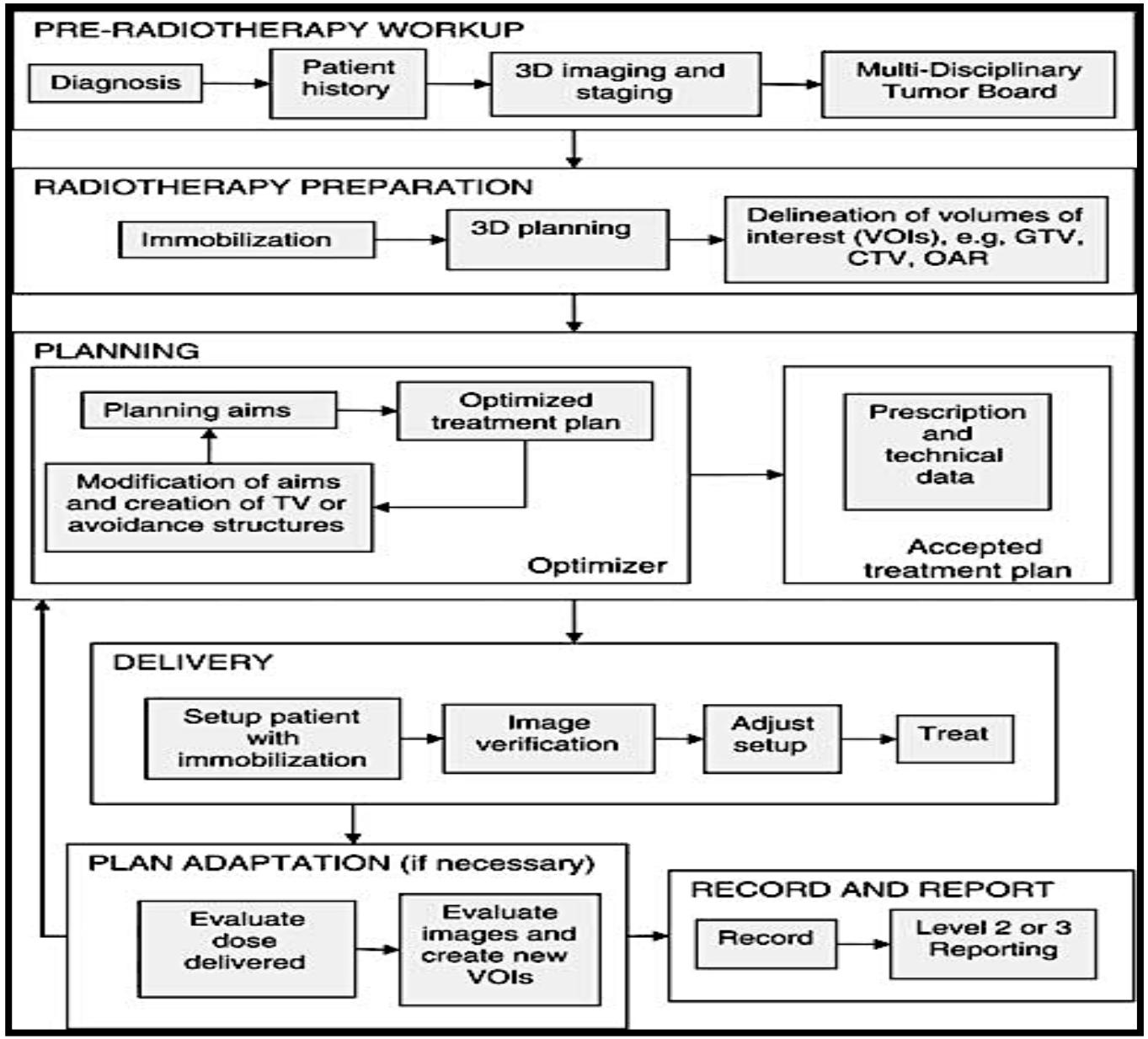
RT PREPARATION

PLANNING

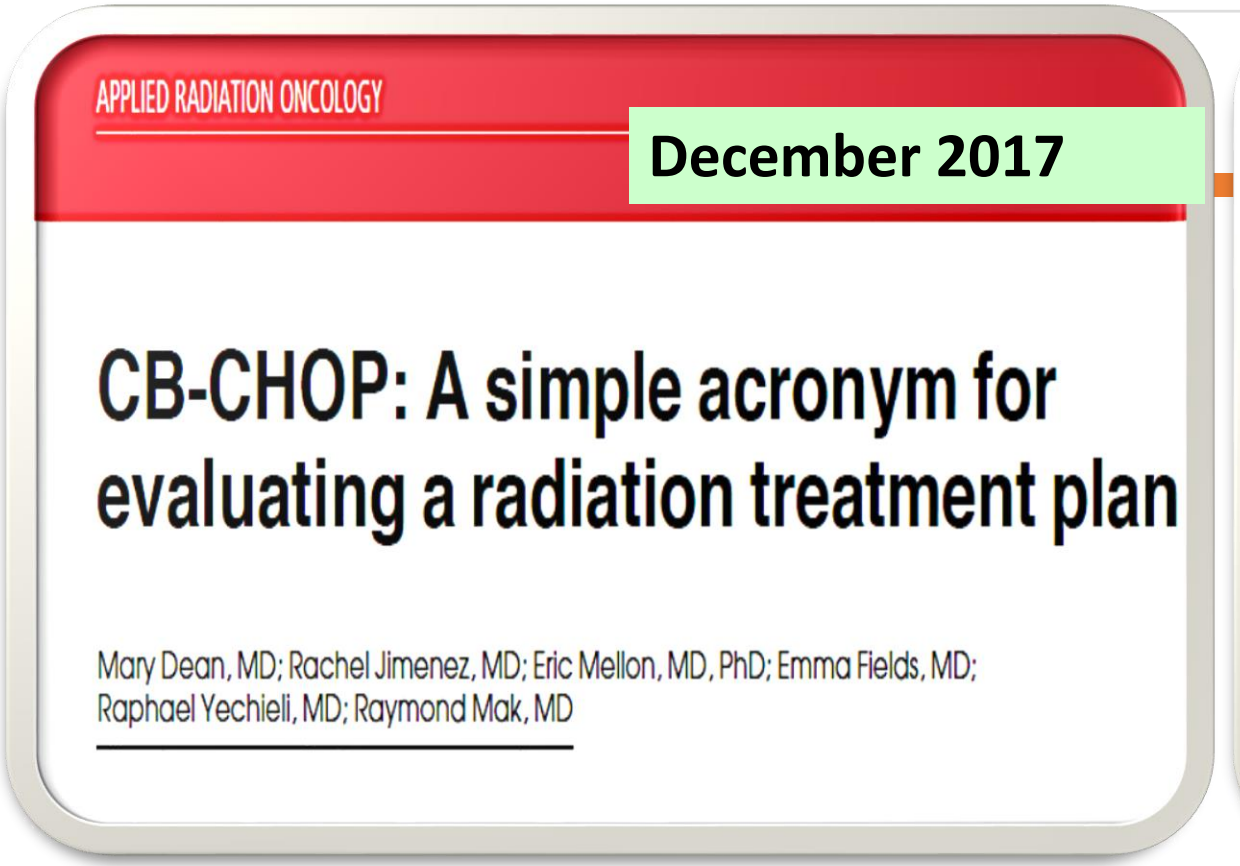
DELIVERY

PLAN ADAPTATION

RECORD / REPORT



Plan Evaluation



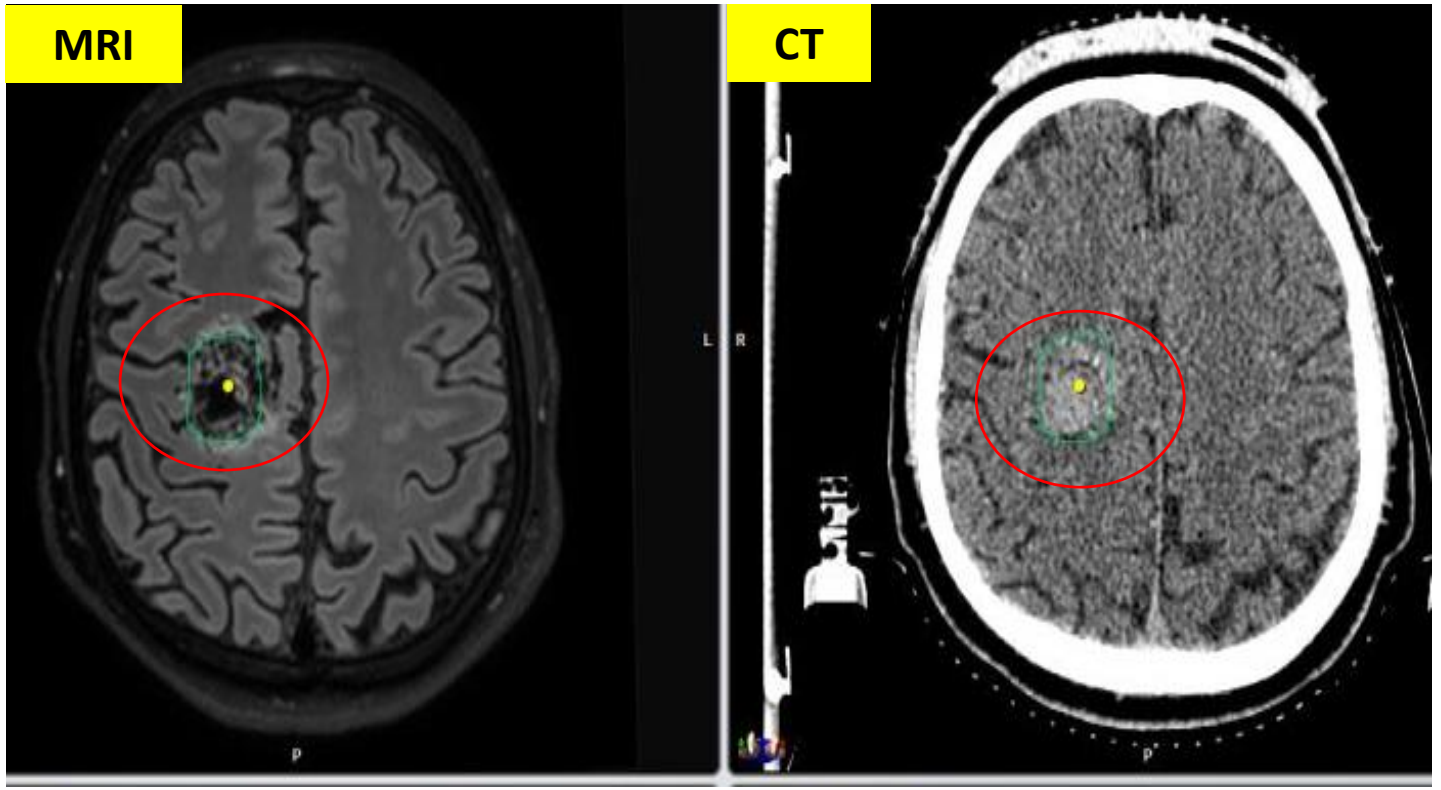
C B C H O P

- **Contours:** Review target volumes and OARS
- **Beam Arrangements/Fields:** Appropriate and reasonable
- **Coverage:** Evaluate on graphic plan and DVH
- **Heterogeneity/Hot Spots:** Value and location
- **Organs at Risk:** Review specified constraints, corresponding isodose lines on plan, and DVH
- **Prescription:** Total dose, dose per fraction, and image guidance

Basic imaging requirements as pre-planning

CT Scan:

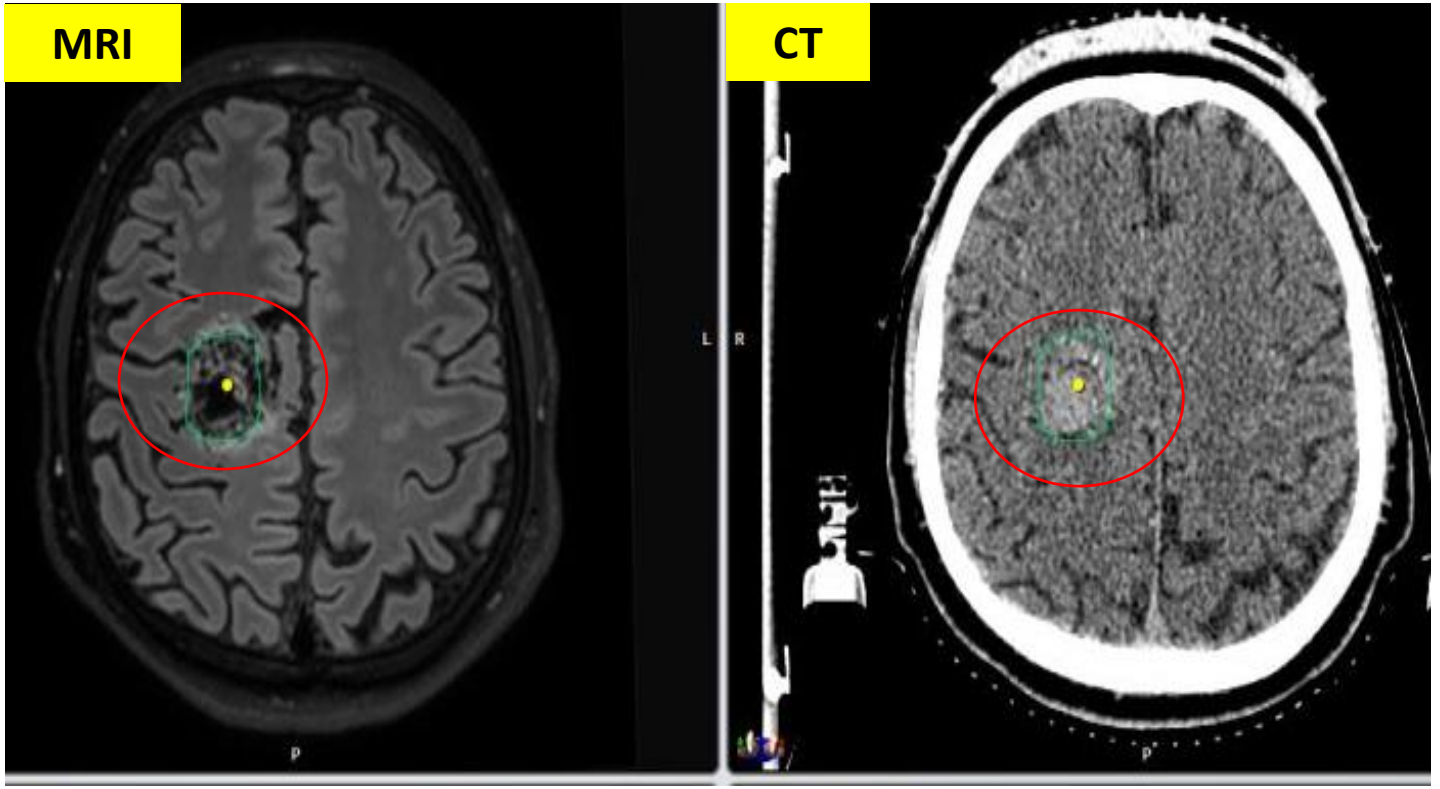
- **Slice thickness- 1mm .**
- **Adequate planning CT scan.**
- **Minimum 10 cm beyond t/t borders (more for Non-coplanar)**
- **Vertex to Neck**



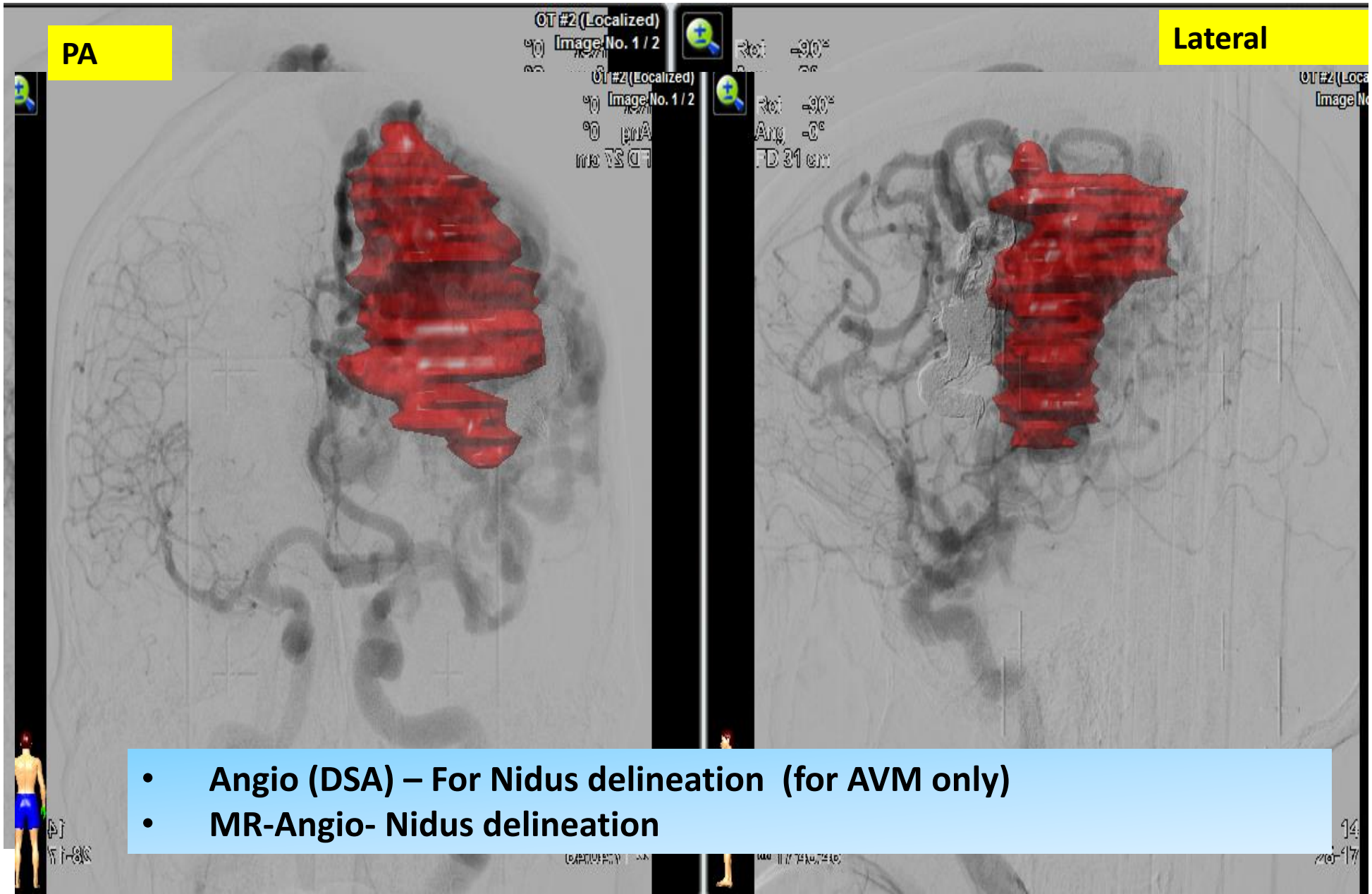
Basic imaging requirements as pre-planning

MRI

- **High resolution Imaging for target delineation- Planning MRI.**
- **(3DFSPGR with contrast.**
- **1mm slice & continuous**
- **No Tilt**
- **DICOM format**

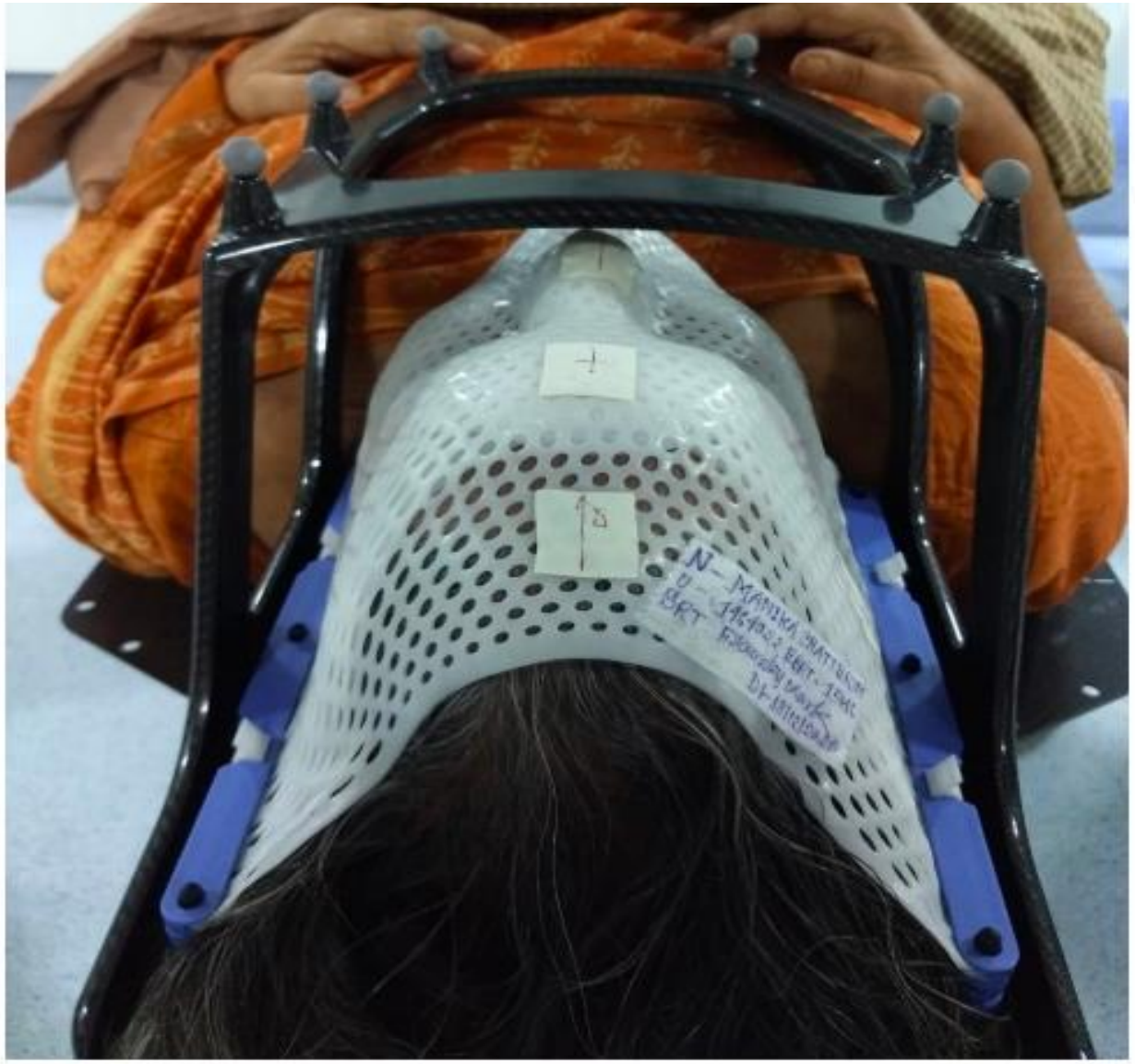


Stereotactic Imaging-DSA (2D Imaging)



- Angio (DSA) – For Nidus delineation (for AVM only)
- MR-Angio- Nidus delineation

Frameless : LINAC Based Stereotaxy

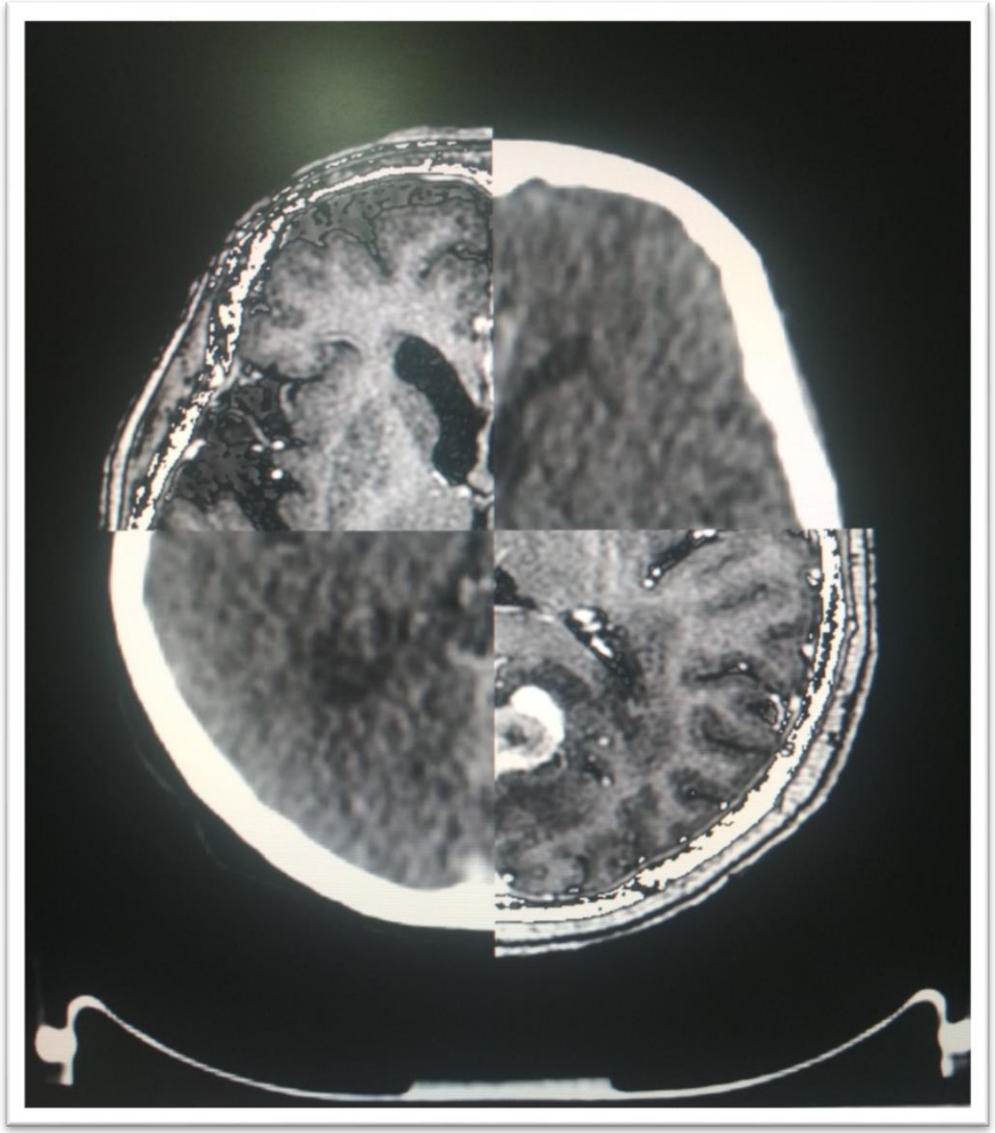


- **Triple layered fine mesh thermoplastic mask used for rigid immobilization.**
- **Planning CT done with a localiser BOX to get a stereotactic co-ordinate.**
- **Localiser Box generates a stereotactic isocentre w.r.t patient anatomy and LINAC isocentre.**

IMAGE FUSION

CT and MRI Fusion

- **Aim to maximize *similarity* between the images.**
- **T1 contrast guides us an exact extent**
- **T2 FLAIR sequence gives us an idea about the edema.**



CONTOURS

- **Review the delineated target volume.**
- **Review if OARs are contoured accurately.**
- **Review if a structure is forgotten / mistakenly not contoured.**
- **Review accuracy of expansions.**

e.g., GTV may have been modified without appropriate re-expansion of the corresponding CTV and PTV not done.

OAR in Brain RT

- **Optic Apparatus :**
  - **Optic Nerve**
  - **Optic Chiasma**
  - **Brainstem**
  - **Hippocampus**
  - **Eye (as a surrogate for retina)**
  - **Lens (replaceable)**
- **Name OAR and PRV separately**
  - **e.g. Left Optic Nerve, PRV Left Optic Nerve**

Dose constrains in brain

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

Scoccianti , 2014, R & O

Delivery Techniques

MLC

VMAT

3DCRT-Static F

IMRT

Cone

1.3DCRT & Confor. Arc

- **Sharp fall off outside PTV**
- **Inhomogeneous dose inside PTV**
- **Multiple non co-planner beam or arc are needed to create conformal dose distributions.**

How to choose the technique

Clinician/Physicist to decide:

- **VMAT : Standard arcs , usually only 1 set of coplanar and 1 set of non-coplanar beams.**
- **VMAT: Easy and first delivery.**
- **3DCRT/IMRT- Multiple beams in non-coplanar geometry.**
- **3DCRT: Longer delivery time.**
- **Ease and comfort of patient is very important.**
- **Imaging like CBCT can't be done in Non coplanar beams.**

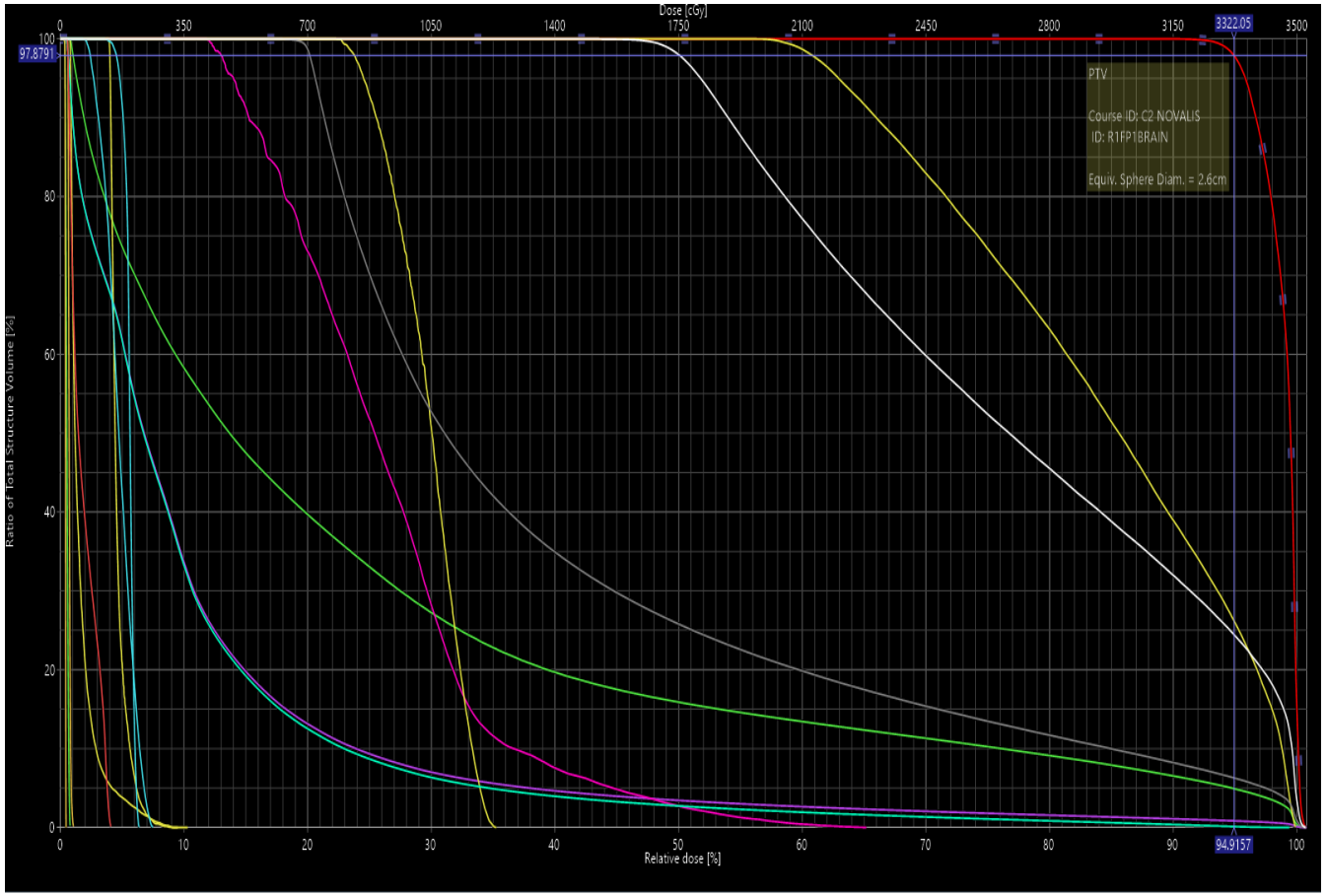
Dose Coverage

- **Ideal GTV $V_{100\,\%} \geq 95\%$ and $V_{90\%} > 99\%$**
- **Dmax – Inside the GTV**
- **Prescription isodose: 50 to 90%**

3DCRT / IMRT: Couch rotation isocentre have to be very accurate

Delivery Techniques:3DCRT

All techniques are equally effective depending on the efficiency of the treatment planner.



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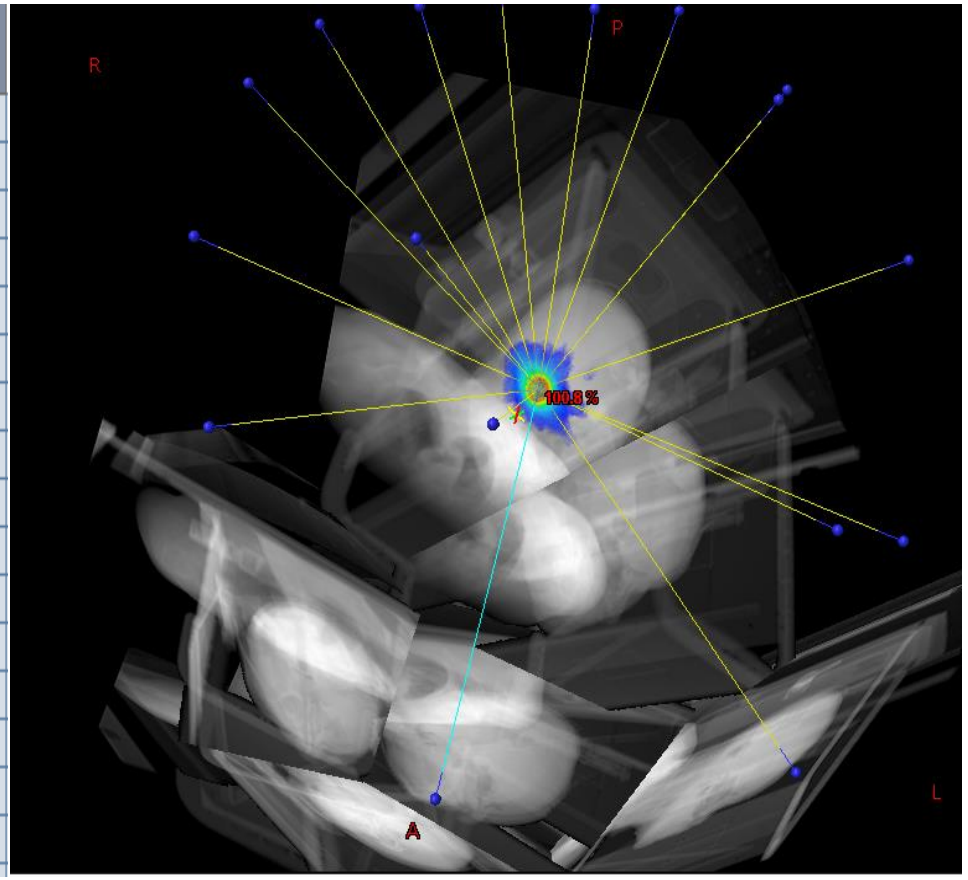
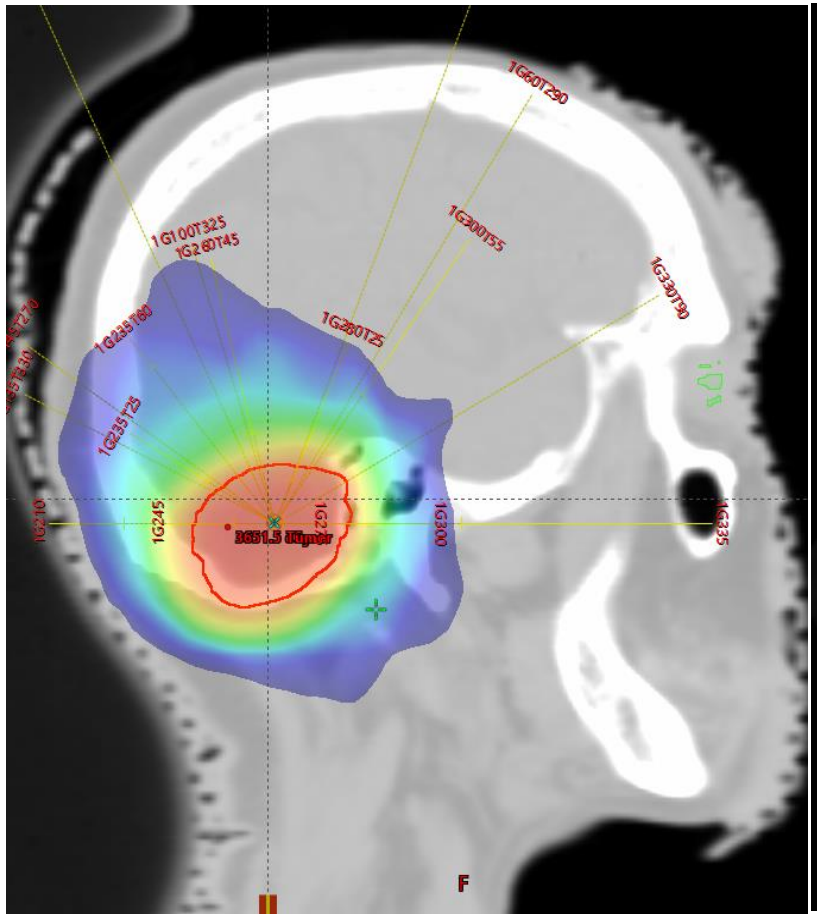
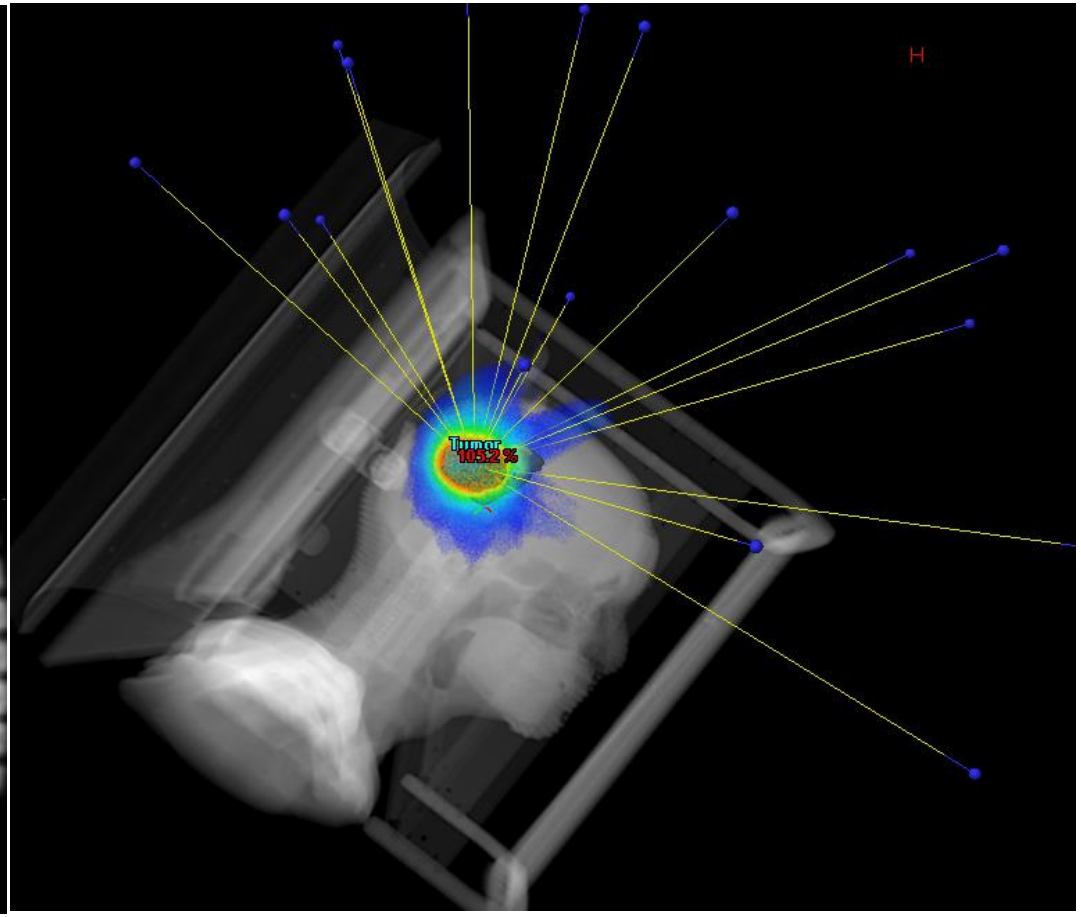
I	1G263
I	1G289
I	1G312
I	1G135T275
I	1G57T290
I	1G112T300
I	1G67T305
I	1G48T335
I	1G225T25
I	1G255T25
I	1G296T35
I	1G251T50
I	1G315T50
I	1GT225T65



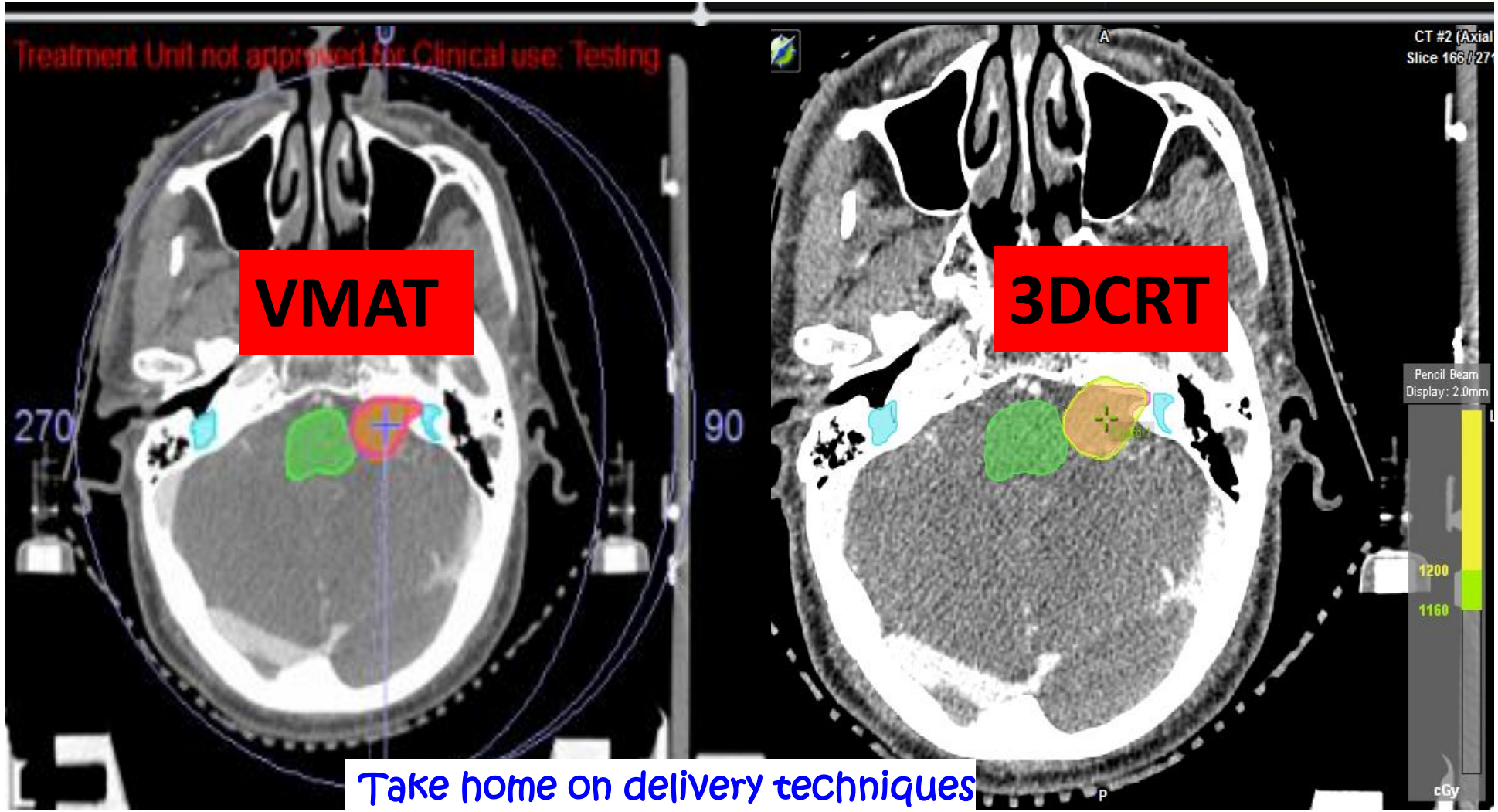
3D CRT – Multiple Coplanar and Non coplanar beams- creates a very confirm dose distribution.

Similarly IMRT can be used effectively Preferably having same beam arrangement that of 3DCRT for similar dose falloff characteristics





3DCRT Vs VMAT

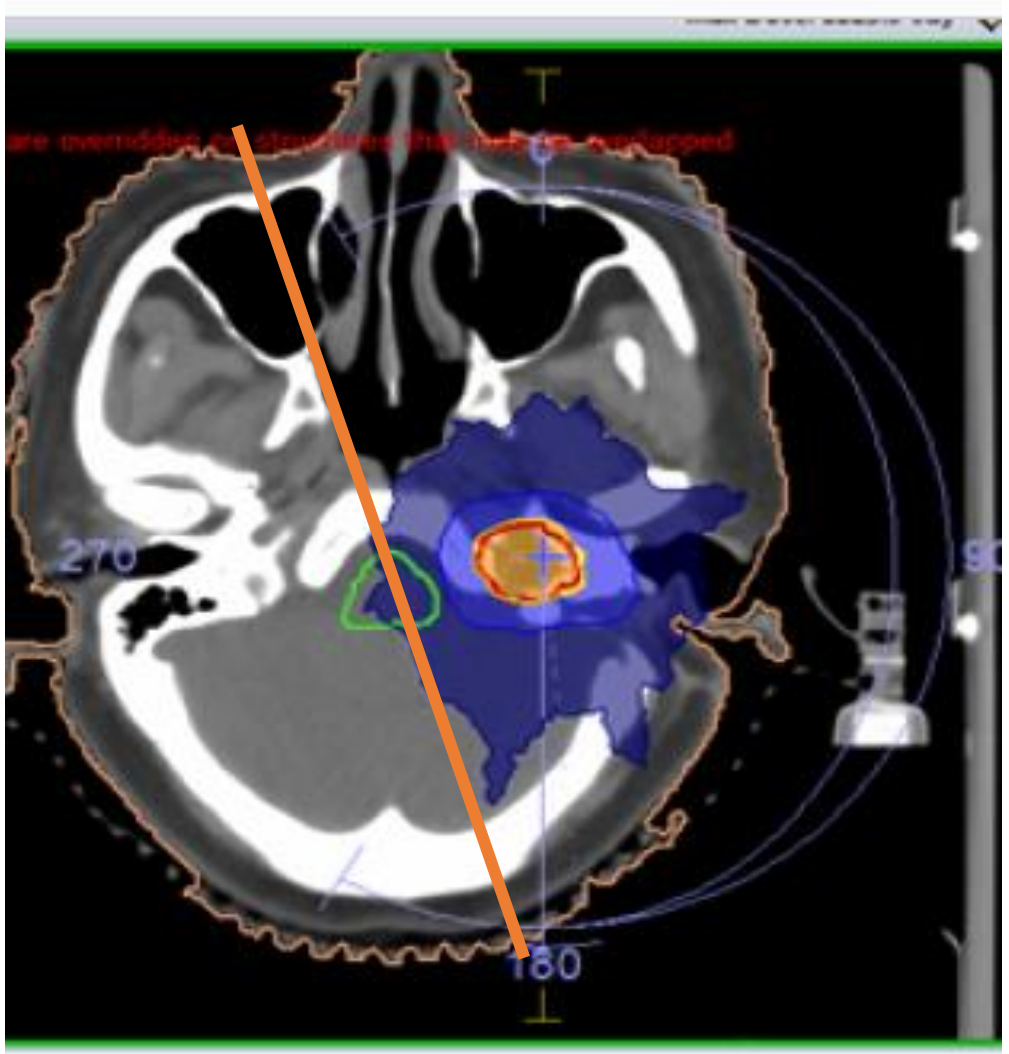


Take home on delivery techniques

- We should’nt get carried away on the techniques.
- Every technique is good to produce a desired dose fall off by efficient treatment planner.

To Remember: Something basic

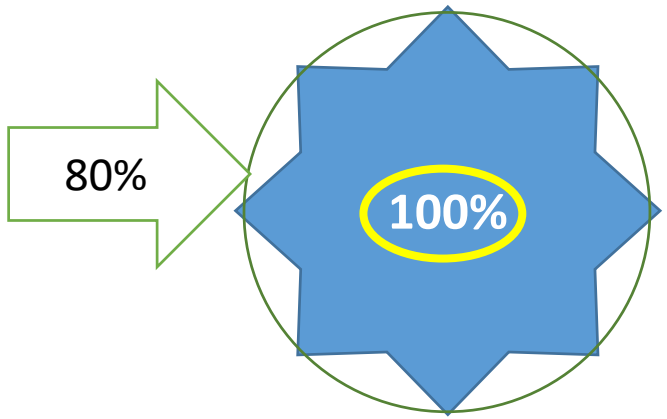
- Try to confine the beams only to the ipsilateral hemisphere of the brain for lateralise tumour.
- Co-planar arcs may be better to avoid low dose spill to normal brain.
- More beams may mean more Monitor units (MUs).
- Avoid entry points in previously treated areas (In Re-RT settings)



Prescription: Linac Based Stereotaxy

Classical X-Knife prescription is 80% coverage with 100% Hot spot

What dose it mean?



Put beams to Create a dose distribution

Find the covering isodose (it may be 93%) – re-normalised it to 80%RxD. So tumour covered by 80% and adjust the hot spot inside the tumour to 100%- by altering beam/arc weights, angle etc

Modern Equivalence

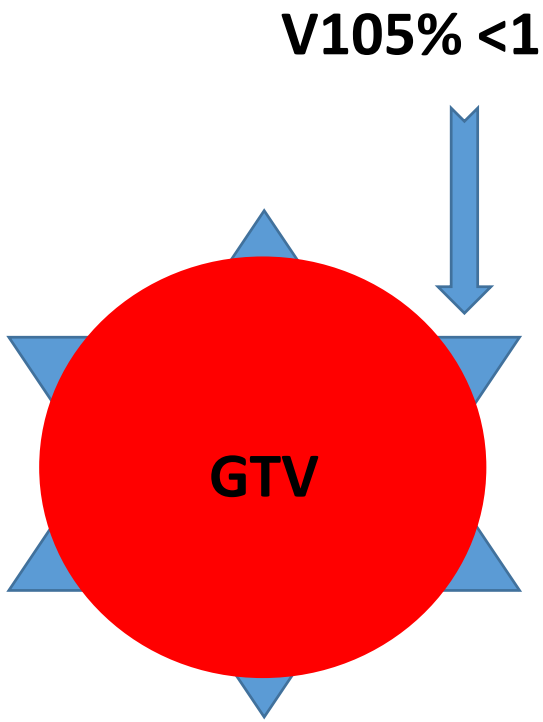
Tumour covered by 100% hot as 120%

Why Shifted ?

As modern TPSes have shifted from relative to volumetric prescription.

High Dose Spillage

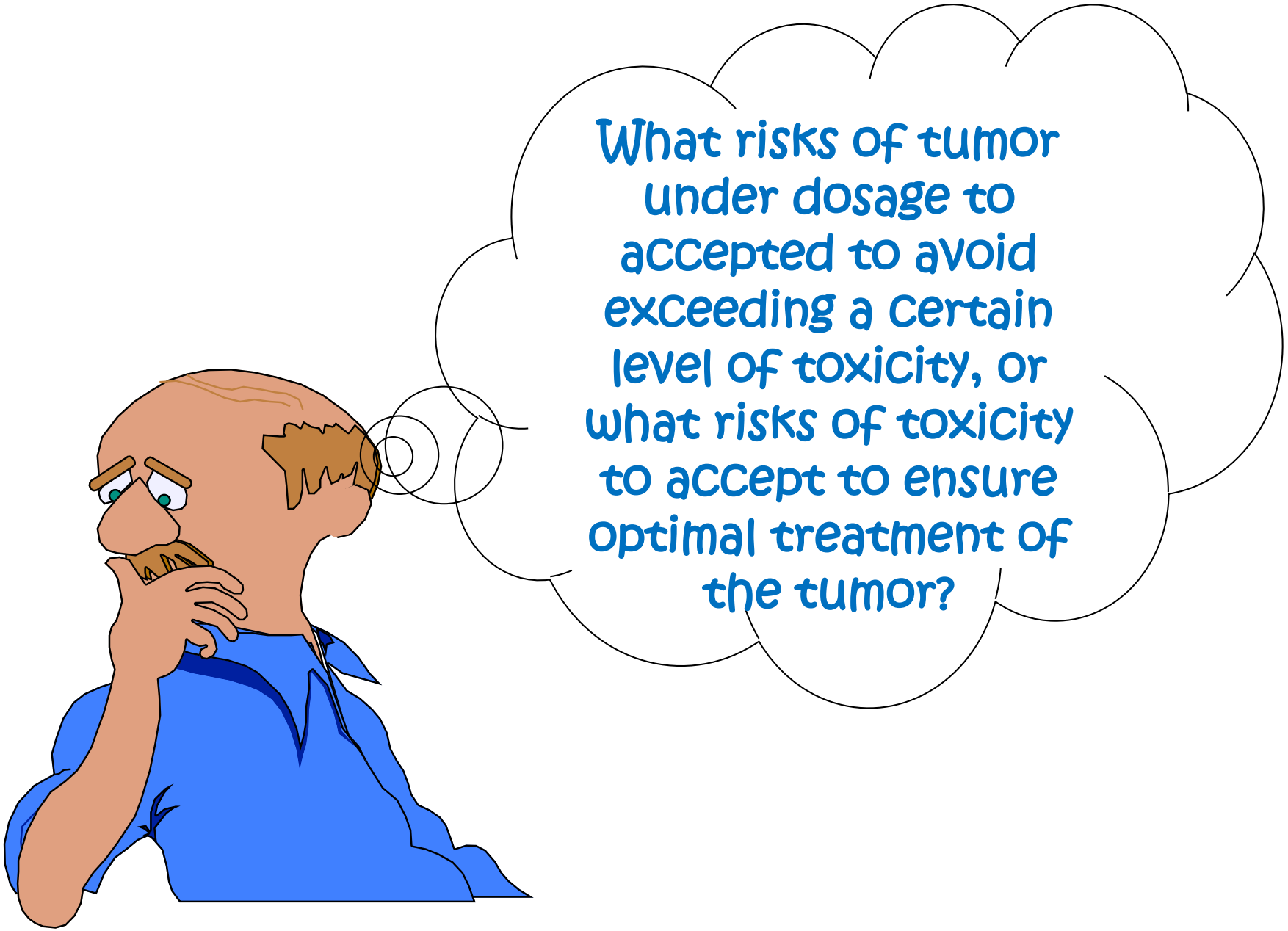
- **$V_{105\%}$ should ideally be < 15% of GTV volume.**



Intermediate Dose Spillage

- $R_{50\%}$ = V50%/GTV volume.
- *Dose gradient: Volume enclosed by 50% isodose*

Ideal value < 4.6


What risks of tumor under dosage to accepted to avoid exceeding a certain level of toxicity, or what risks of toxicity to accept to ensure optimal treatment of the tumor?

Prescription: Linac Bases Steriotaxy

Core Hot Or Cold or Uniform Plan?

Depends on the clinical scenario
(Volume of hypoxic cell , vicinity of OAR's)

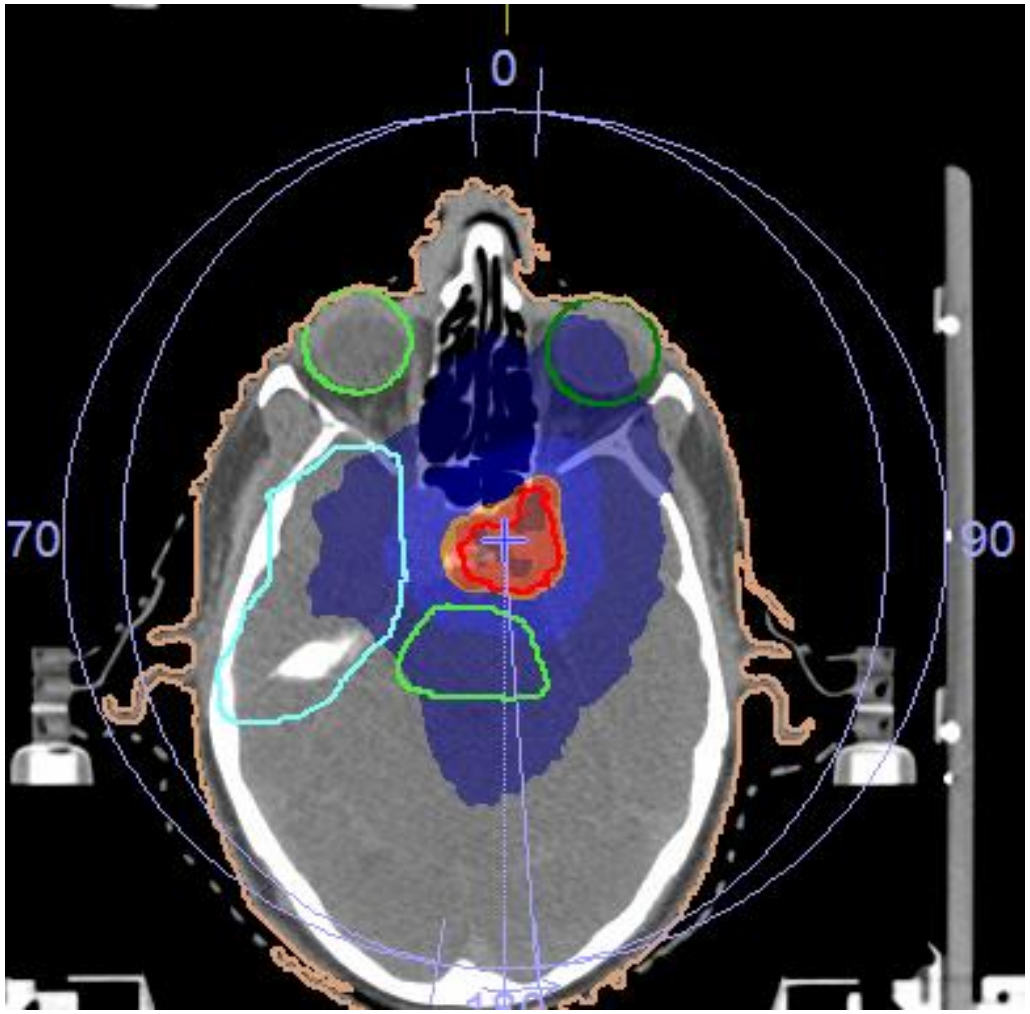
CORE UNIFORM

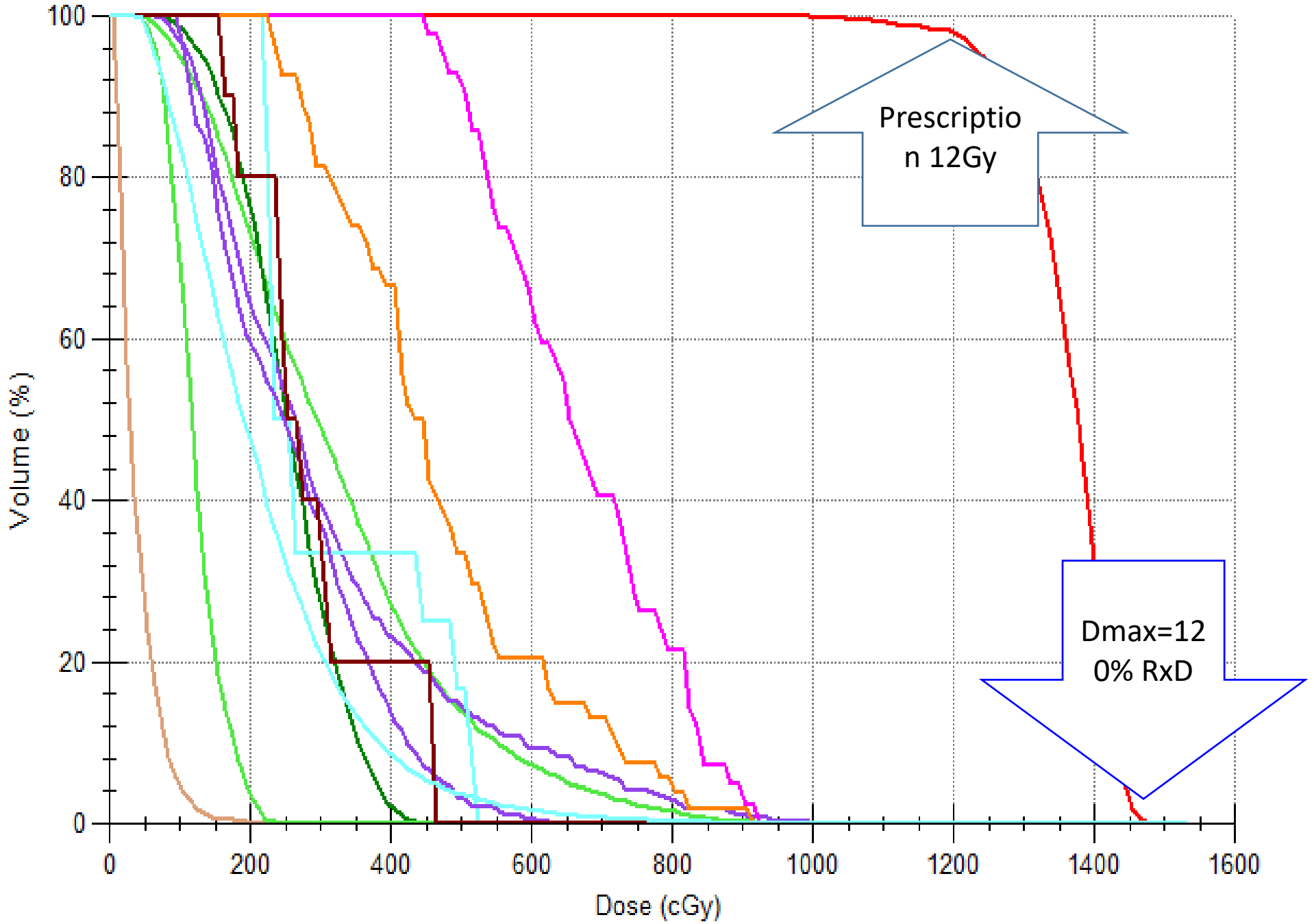
D(100%-98%)→V(100%-98%)
Dmax ≤110%

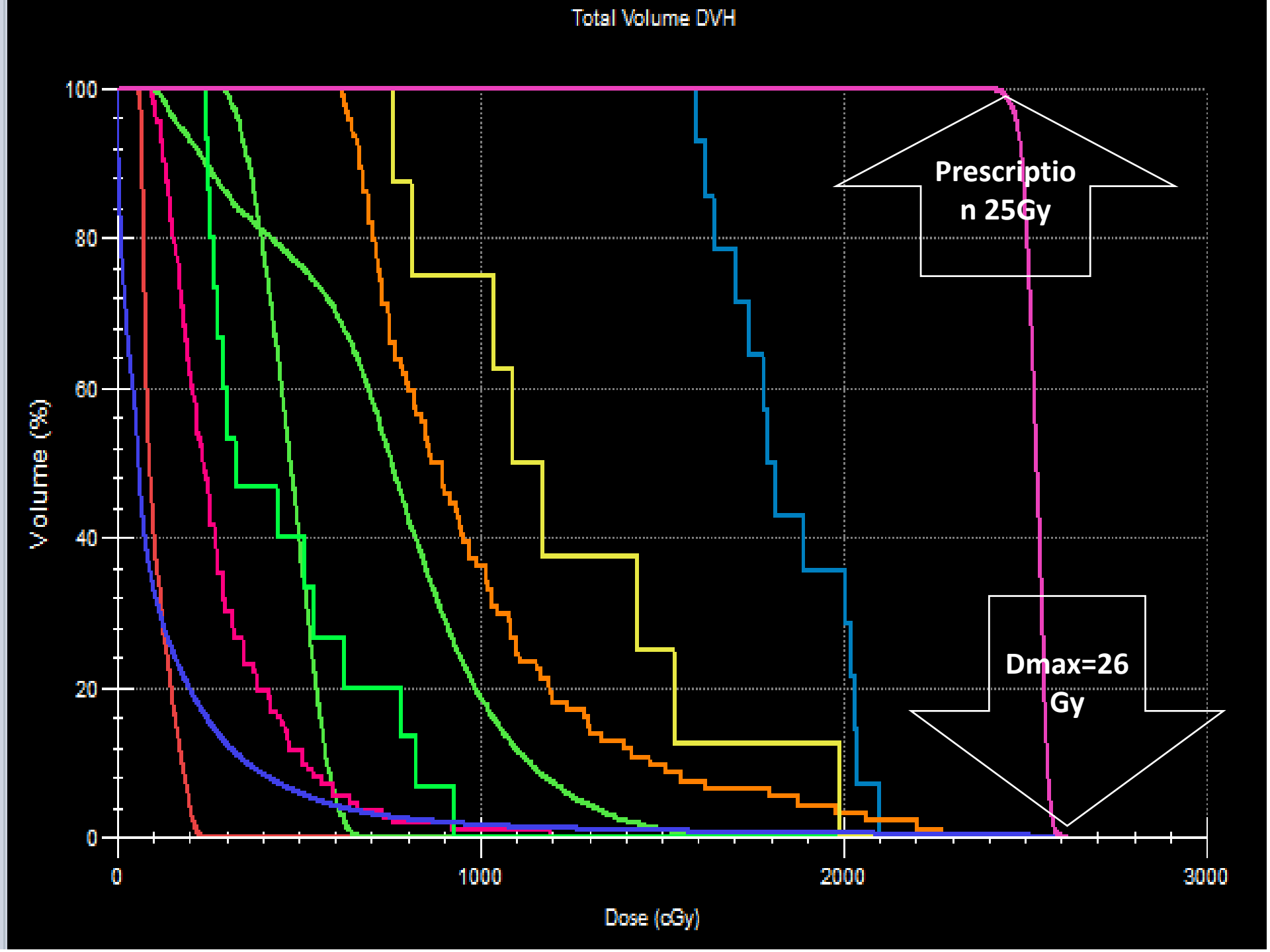
or

CORE HOT

D(100%-98%)→V(100%-98%)
Dmax ≤ 120% at the core



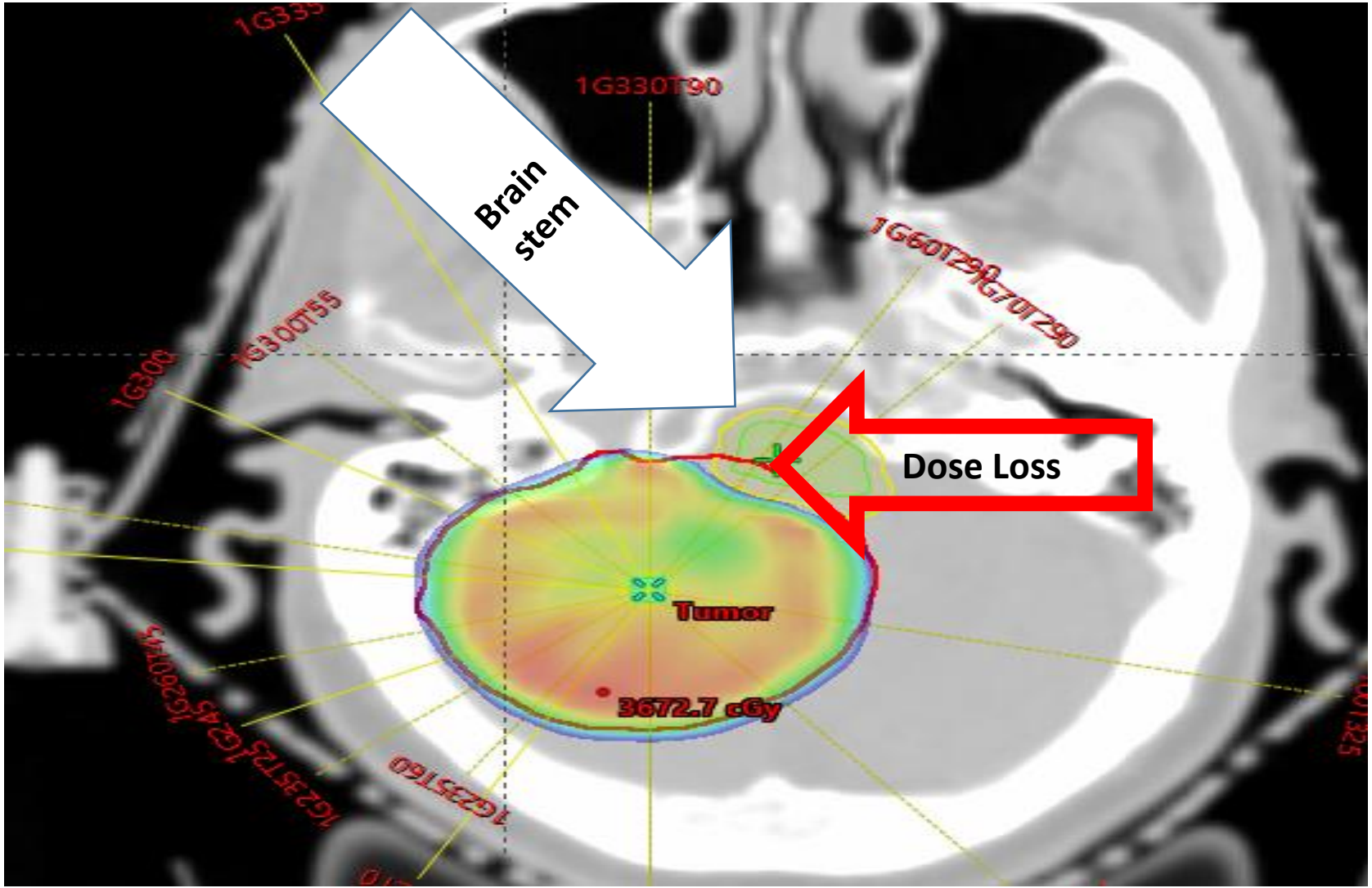

Prescriptio
n 12Gy
Dmax=12
0% RxD
Volume (%)
Dose (cGy)
100
80
60
40
20
0
0
200
400
600
800
1000
1200
1400
1600


Total Volume DVH
Volume (%)
100
80
60
40
20
0
0
1000
2000
3000
Dose (cGy)
Prescriptio
n 25Gy
Dmax=26
Gy

Can we always get good dose distribution??

Yes : For isolated tumours

No : For OAR invaded tumours

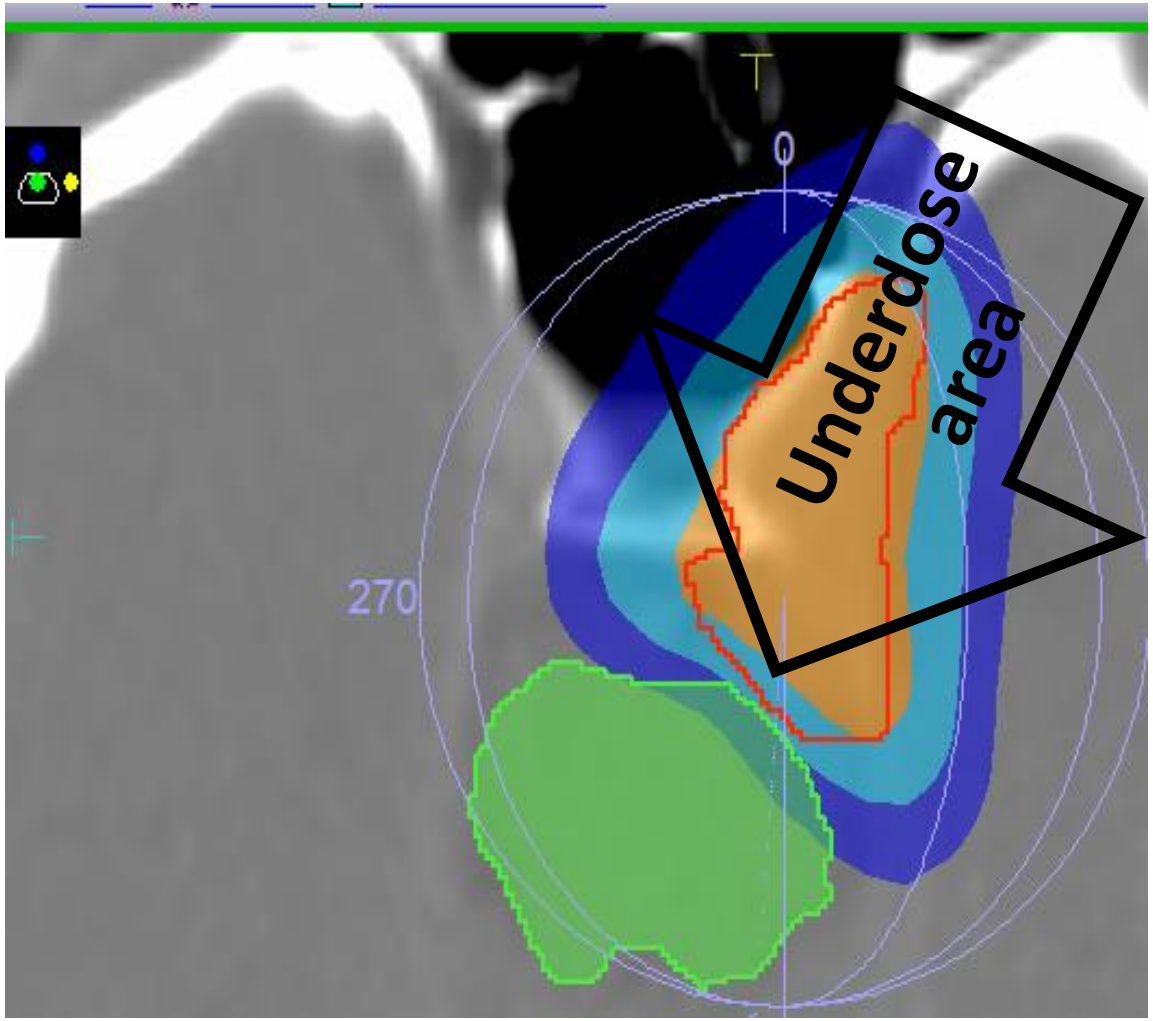


What to do if PTV is abutting an OAR (Brainstem) ?

1st option:
Compromise the PTV:
As you are not supposed to change the OAR.

2nd option:
Do not compromise the PTV:
Use PTV Under Dosing (*in Selective areas*) to achieve OAR tolerance doses.

2nd option is commonly opted.



Some Definitions: What is Coverage and Spillage?

Target Coverage

$$c = \frac{V_D \, x \, V_T}{V_T}$$

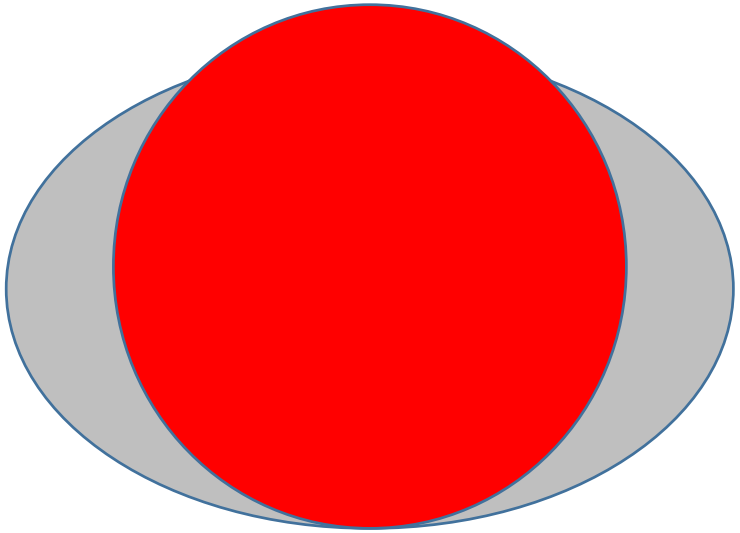
Coverage

Plan Selectivity

$$s = \frac{V_D \, x \, V_T}{V_D}$$

Spillage

VT = Target volume



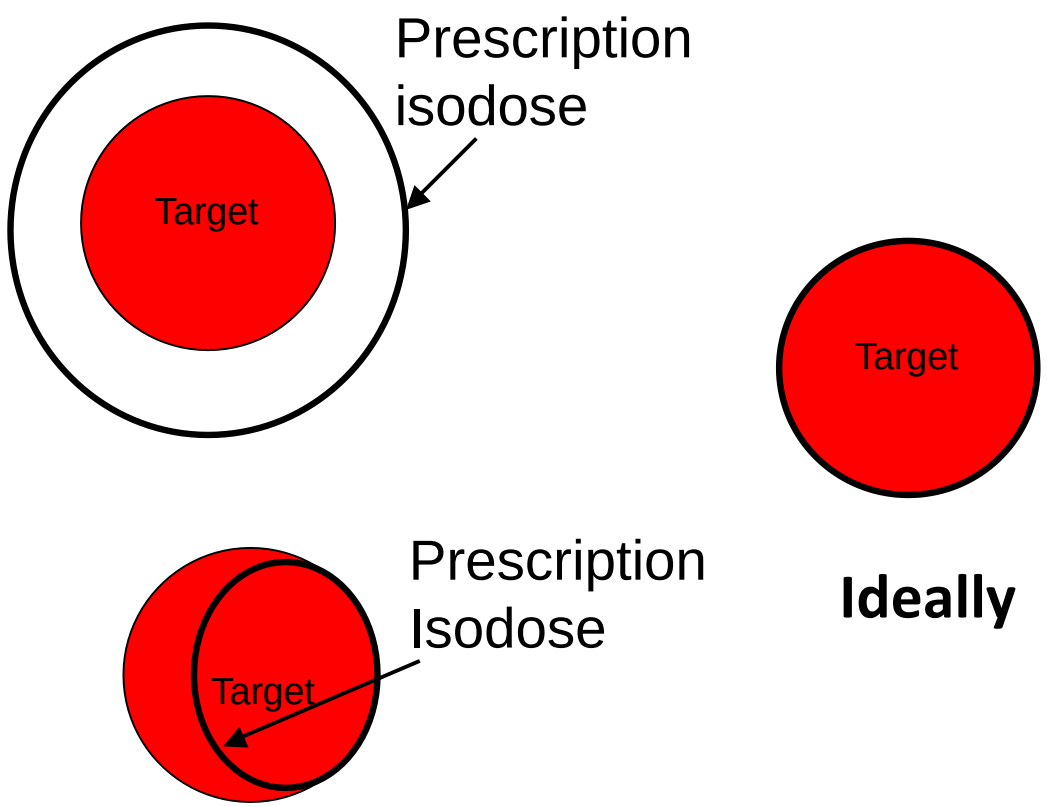
VD = Volume receiving dose D
(i.e prescription volume)

D = Prescription dose

Coverage versus Selectivity

- Excellent target coverage, poor selectivity

- Excellent selectivity, poor target coverage



Heterogeneity/hot spot

- In a conventional fractionated IMRT plan, the acceptable minimum dose in the PTV is often around 95% with maximum around 115% of the prescribed dose.

- A hot spot within the PTV is acceptable as opposed to its being within the critical organs.

- A cold spot at the edges of the PTV is preferred to it being within the GTV or CTV.

International Commission on Radiation Units and Measurements, Inc.

ICRU 83 – Homogeneity & Conformity

Homogeneiy index is defined as,

$$HI = \frac{D_{2\%} - D_{98\%}}{D_{50\%}}$$

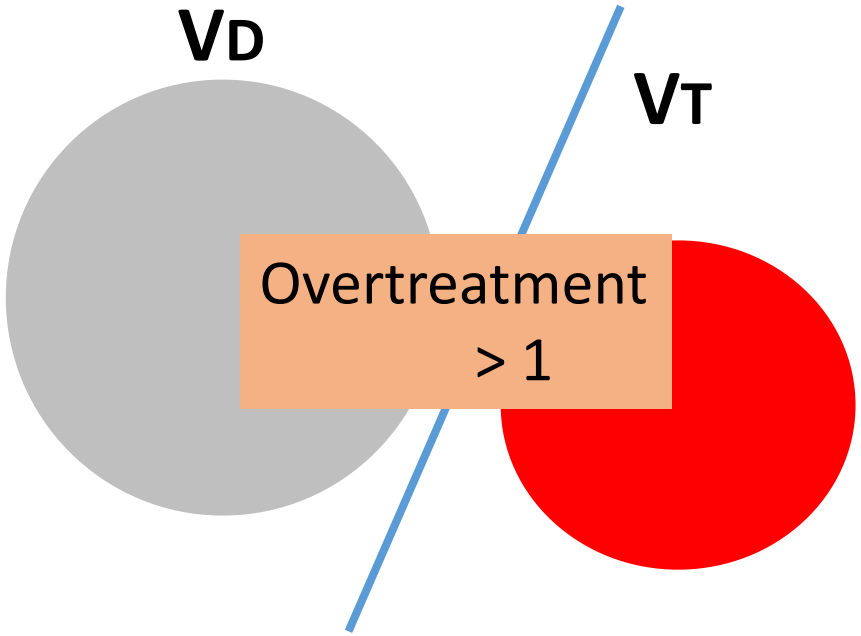
Dose-volume reporting
- D50% (Dmedian), Dose received by 50% of PTV
- D98% : Dose received by 98% volume of PTV
- D2% : Dose received by 2% volume of PTV

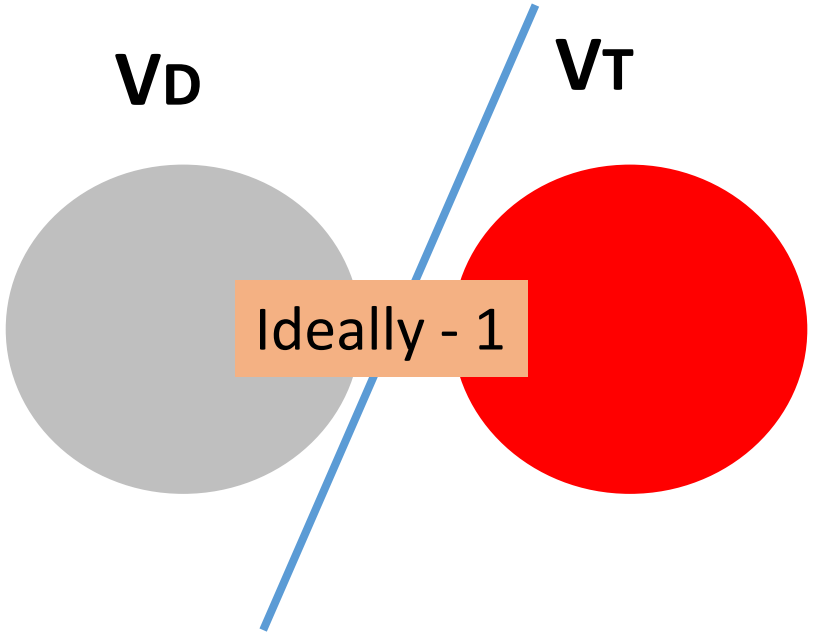
Dose homogeneity characterizes the uniformity of the absorbed-dose distribution within the target .

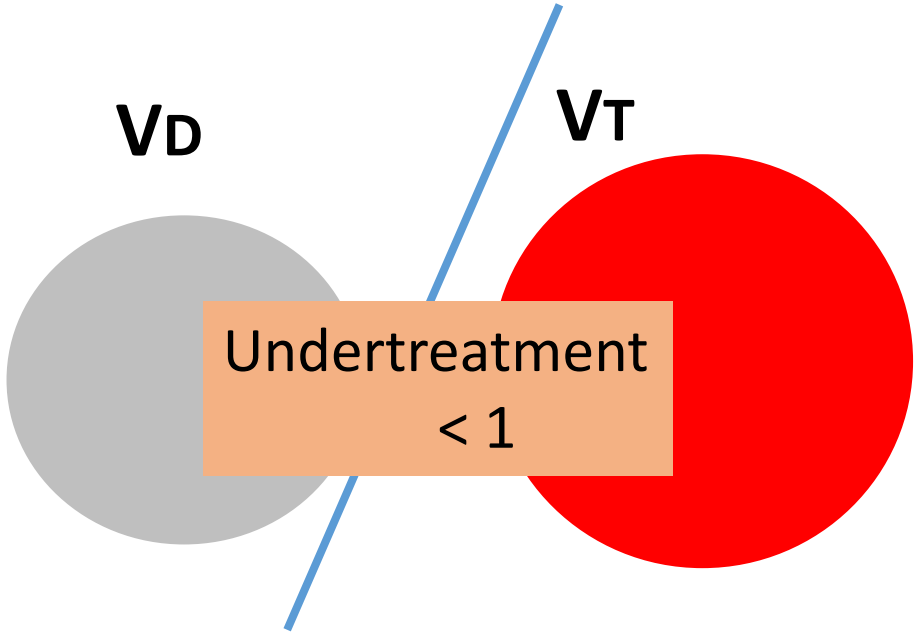
Conformity Index

RTOG conformity index*:

$$C_S = \frac{V_D}{V_T} = \frac{c}{s}$$







*E. Shaw et al., Int. J. Radiat. Oncol. Biol. Phys. **27**, 1231-1239 (1993).

Conformity Indices

RTOG conformity index*:

$$C_S = \frac{V_D}{V_T} = \frac{c}{s}$$

Usually ″ *1, but can be < 1 if coverage is sub-optimal.*

Paddick conformity index:**

$$C_P = c \, x \, s$$

$$s = \frac{V_D \, ^x V_T}{V_D} \qquad c = \frac{V_D \, ^x V_T}{V_T}$$

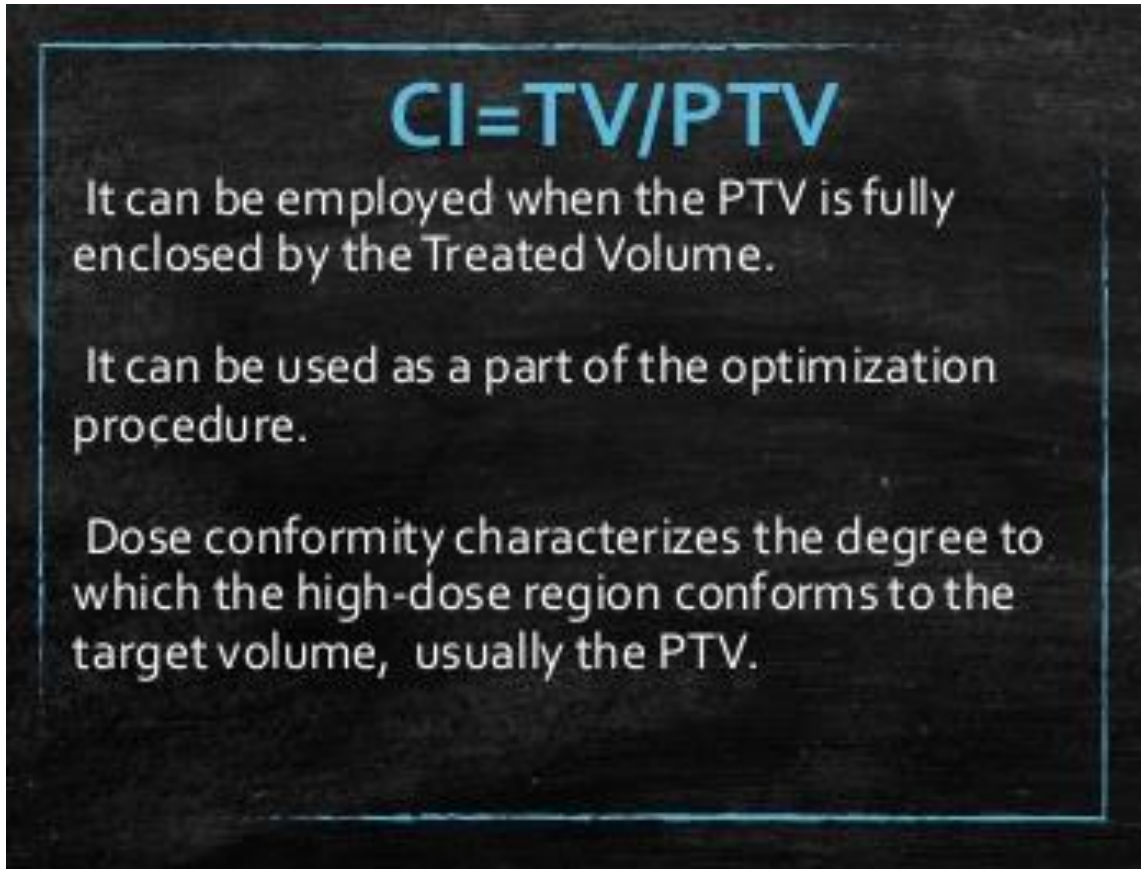
Always # 1

C_P = 1 represents perfect conformity

*E. Shaw et al., Int. J. Radiat. Oncol. Biol. Phys. **27**, 1231-1239 (1993).

I. Paddick, J. Neurosurg. (Suppl) **93, 219-222 (2000).

Dose conformity



- CI – must be between 1 – 2,
- CI of 0.9 – 1 & 2 – 2.5 means minor violation
- CI of < 0.9 & > 2.5 means major violation
- Increasing availability & use of DVH formats for dose reporting, make these indices less relevant in IMRT.

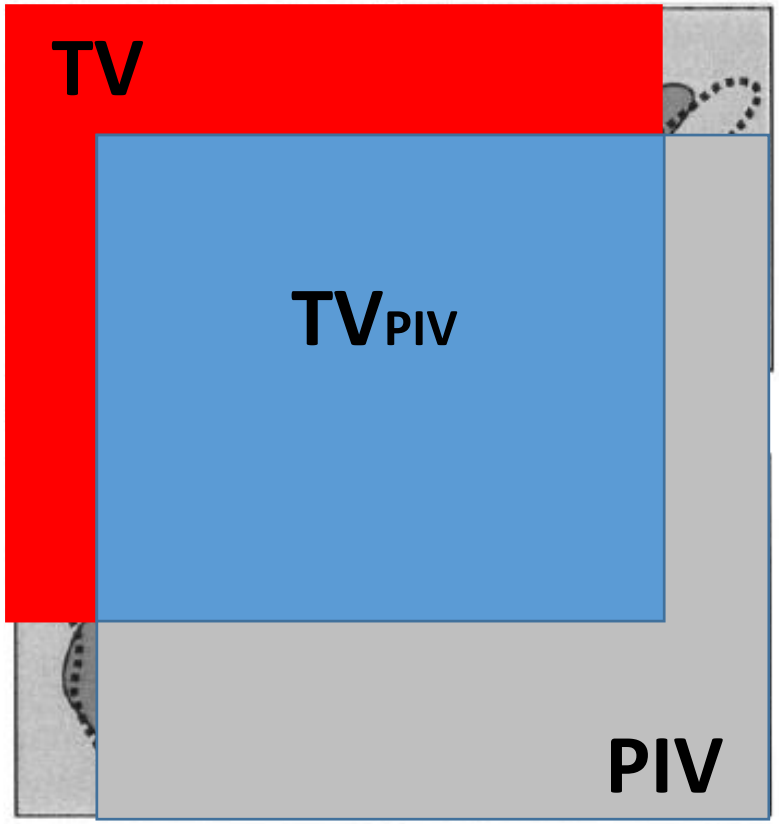
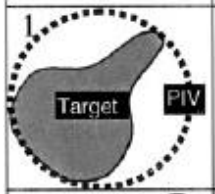
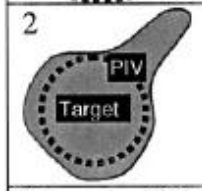
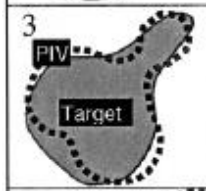
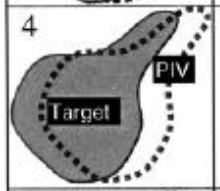
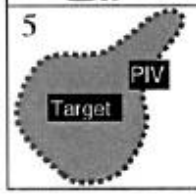


FIG. 1c.

FIG. 1d.

Isodose Plan	Parameters	PITV	RCI_I	Proposed Index
		$\frac{PIV}{TV}$	$\frac{TV_{PIV}}{TV}$	$\frac{TV_{PIV}^2}{TV \times PIV}$
1 	$TV = 5cm^3$ $TV_{PIV} = 5cm^3$ $PIV = 10cm^3$	2.00	**1.00**	0.50
2 	$TV = 5cm^3$ $TV_{PIV} = 3cm^3$ $PIV = 3cm^3$	0.60	0.60	0.60
3 	$TV = 5cm^3$ $TV_{PIV} = 4cm^3$ $PIV = 5cm^3$	**1.00**	0.80	0.64
4 	$TV = 5cm^3$ $TV_{PIV} = 3cm^3$ $PIV = 5cm^3$	**1.00**	0.60	0.36
5 	$TV = 5cm^3$ $TV_{PIV} = 5cm^3$ $PIV = 5cm^3$	1.00	1.00	1.00

I. Paddick, J. Neurosurg. (Suppl) **93**, 219-222 (2000).

Relationship between Shaw (RTOG) and Paddick Conformity Indices

$$C_P = \frac{c^2}{C_S}$$

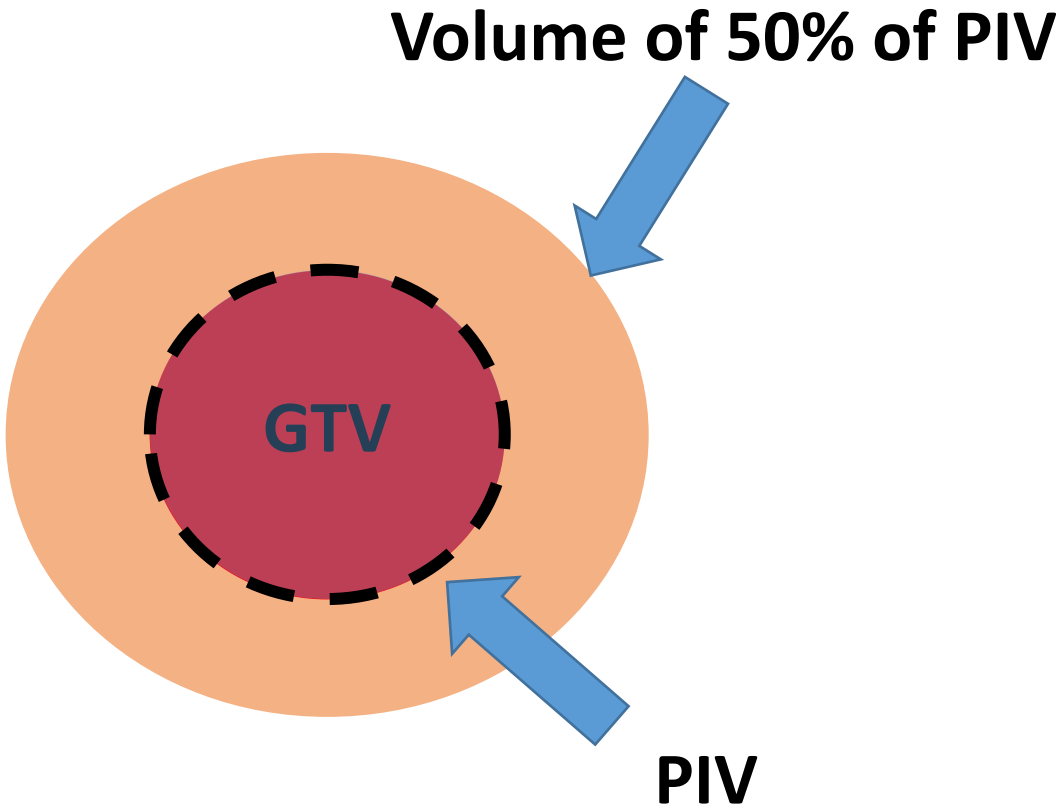
- C_P is inversely proportional to C_S, with proportionality constant equal to the square of the target coverage
- $C_P = 1/C_S$ if the target coverage is 100% (i.e., $c = 1$)
- In GK SRS we seem to be moving towards using C_P

Gradient Index

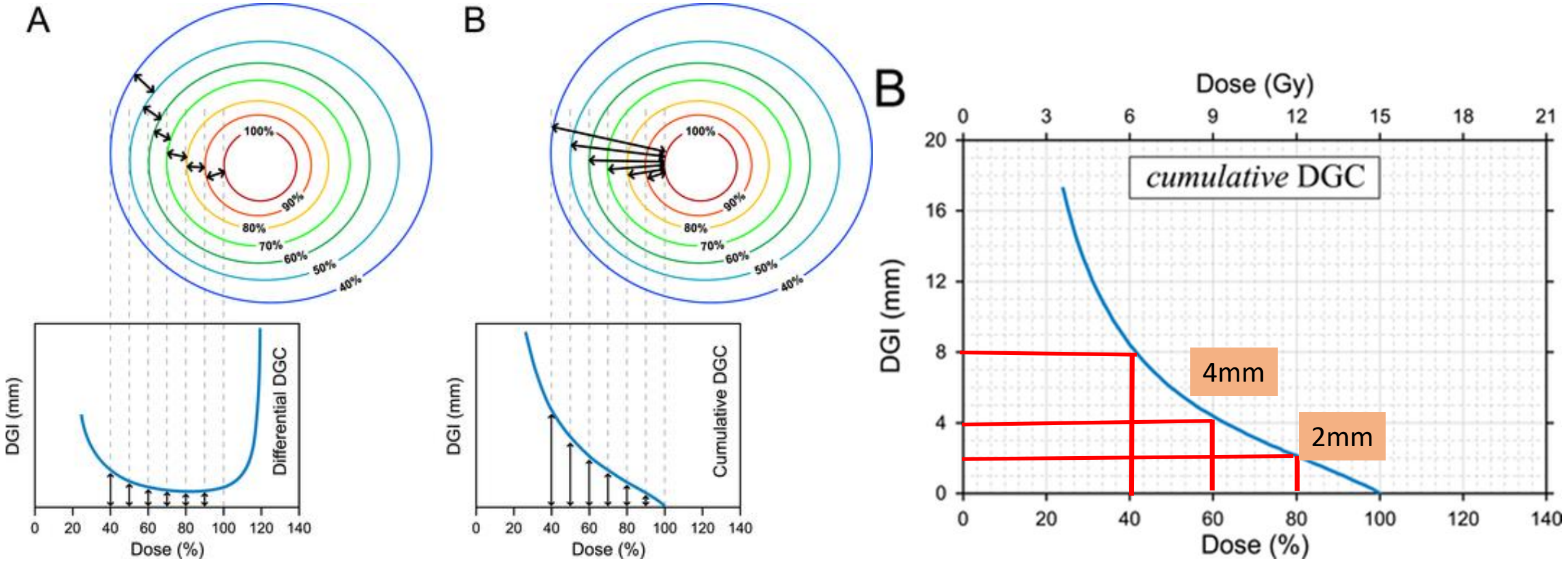
$$GI = \frac{\text{Volume of 50\% of PIV}}{\text{PIV}}$$

(Prescribed Isodose Volume)

Ideal Value ~ 3



Schematic representation of the basic concept of the dose gradient curves (DGC).

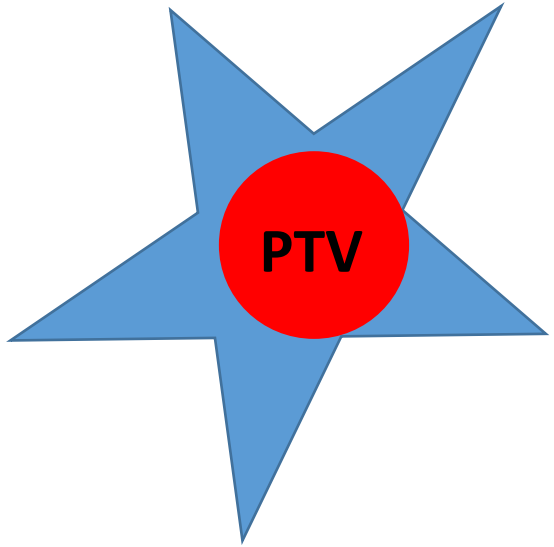


Sung K, Choi YE (2018) Dose gradient curve: A new tool for evaluating dose gradient. PLOS ONE 13(4): e0196664. https://doi.org/10.1371/journal.pone.0196664
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0196664

INTERMEDIATE DOSE SPILLAGE

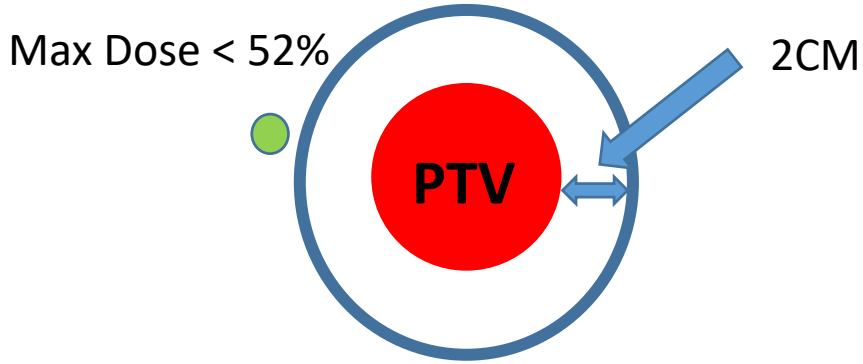
- $R_{50\%}$ = V50%/PTV volume.

Ideal value < 4.6



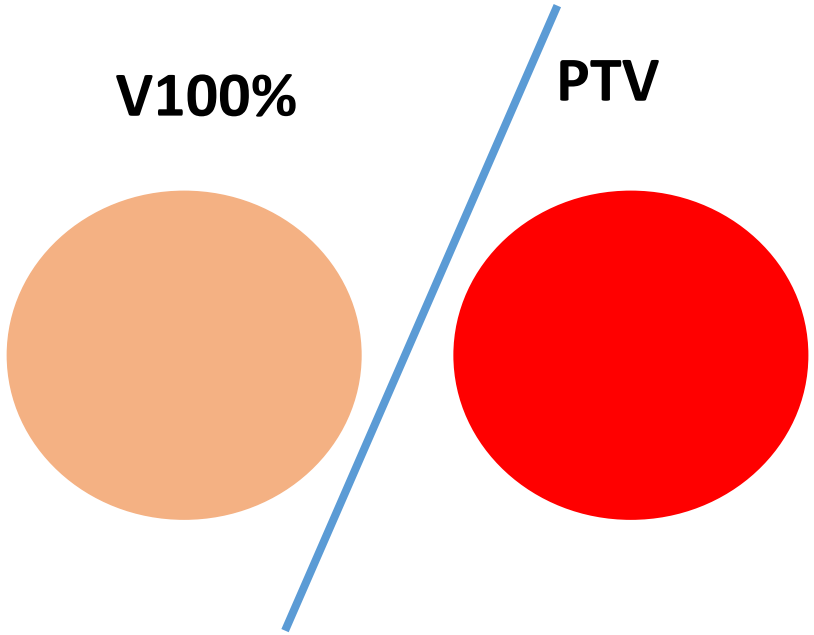
- D_{2cm} = maximum dose in % of prescribed dose at 2 cm beyond the PTV in any direction.

Ideal value < 52.7%



CONFIRMITY

- Defined by the conformity index ---$V_{100\%}$/PTV volume.
- Ideal value ≤ 1.2



Delivery

- Setup
- Imaging
- Verification

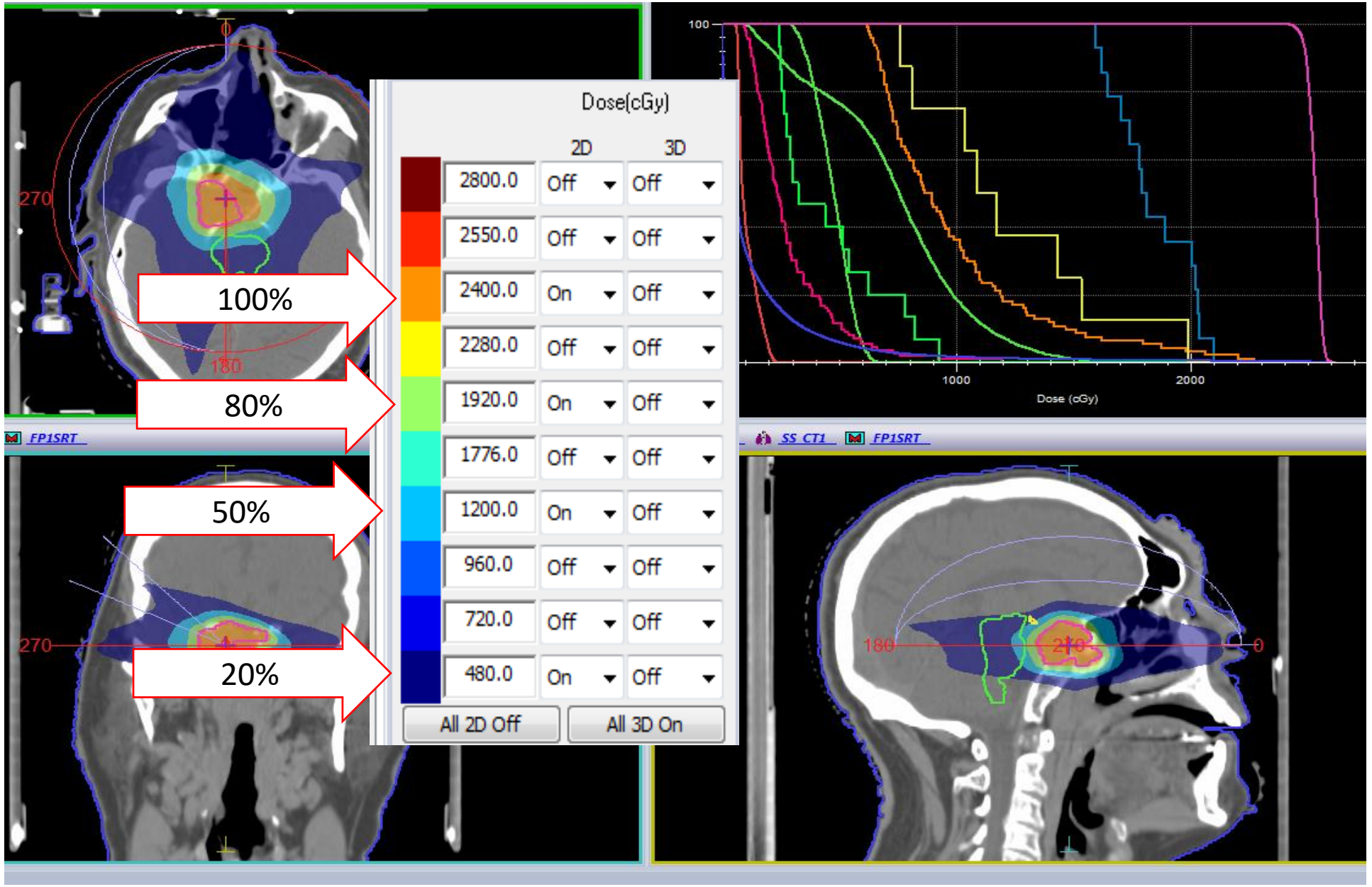
- 3DCRT– Absorbed Dose in the PTV be confined within 95% - 107% of the prescribed absorbed dose

- In IMRT these constraints should not be followed if avoidance of normal tissue is more important than target dose homogeneity.

- ICRU 83 – Extent of high & low dose regions are specified using Dose – Volume metrics like $D_{2\%}$ & $D_{98\%}$ respectively.

- In IMRT small regions of low or high dose can develop when avoidance of sensitive structure is of prime importance.

Evaluation of Dose distribution



Evaluation of Dose distribution

Set your eye for the dose distribution

See it only in absolute

→ Thoroughly pass through all the slices first only with the dose coverage (98% , 100% or as desired)

→ Only with **hot spot** 108% or 120%

→Check the distance of hotspot with the OAR-

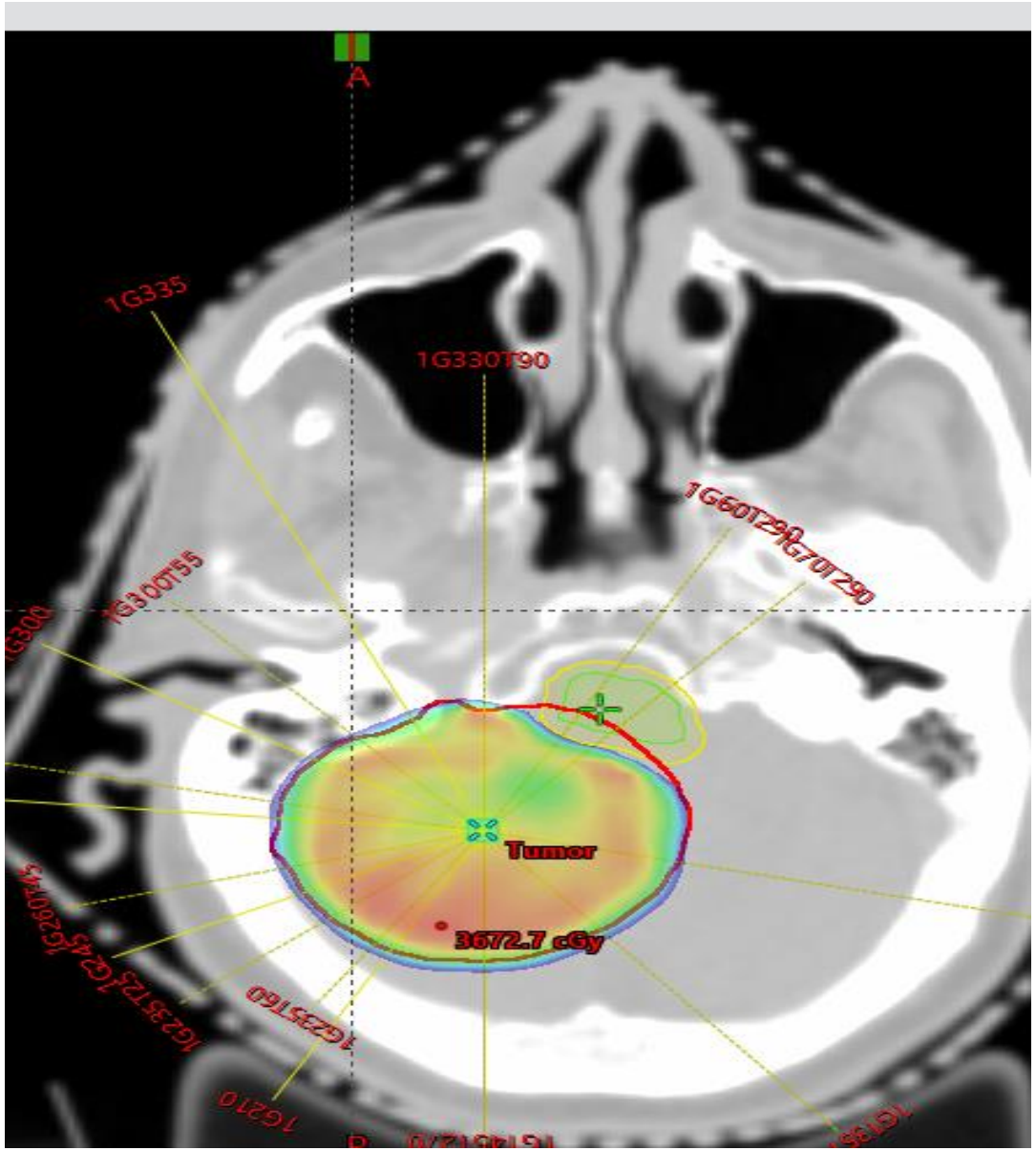
Check it is well distanced

- **Otherwise re-optimize**

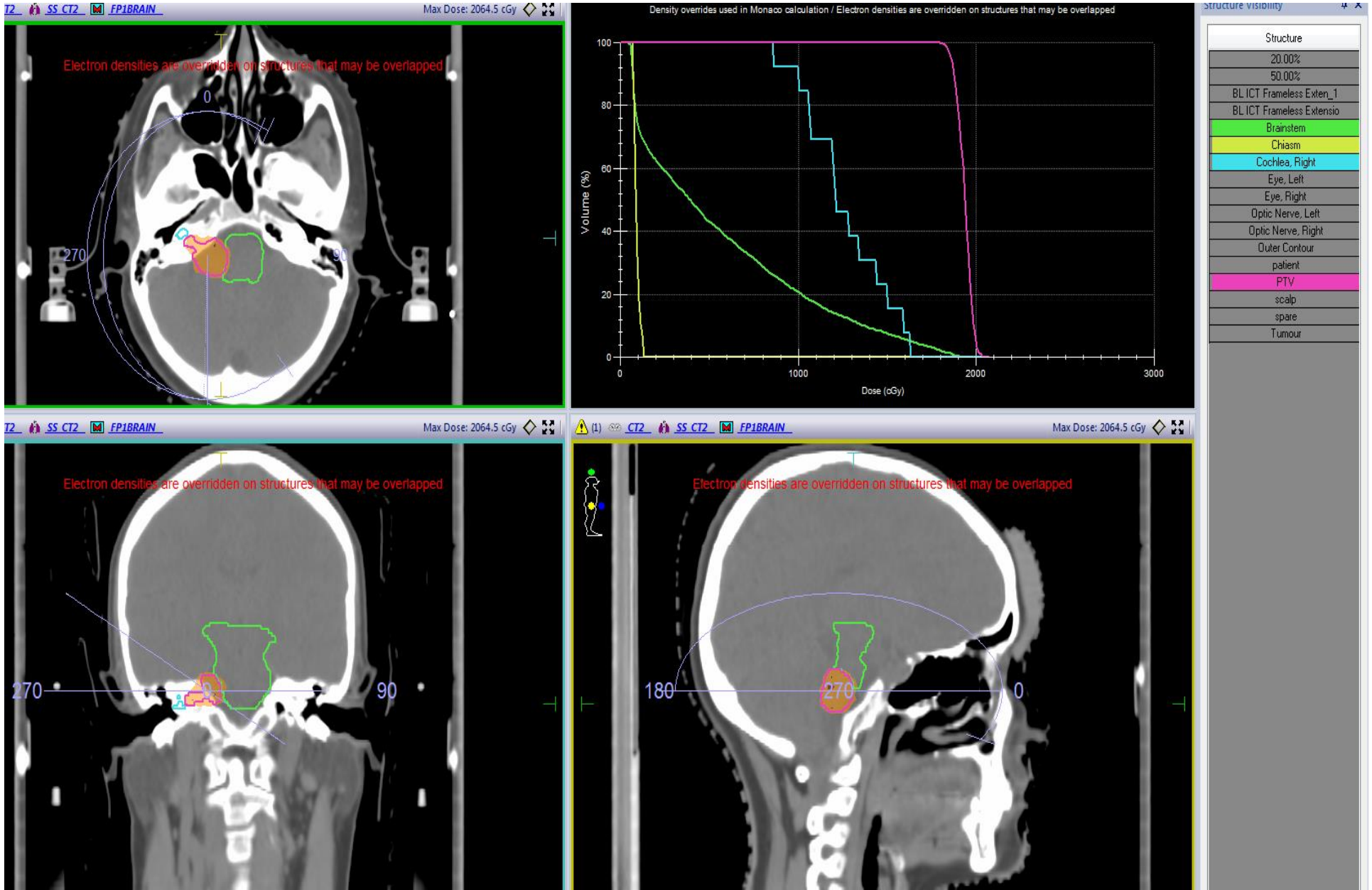
→**Now low dose**

Switch of 50% isodose and scroll through all sections

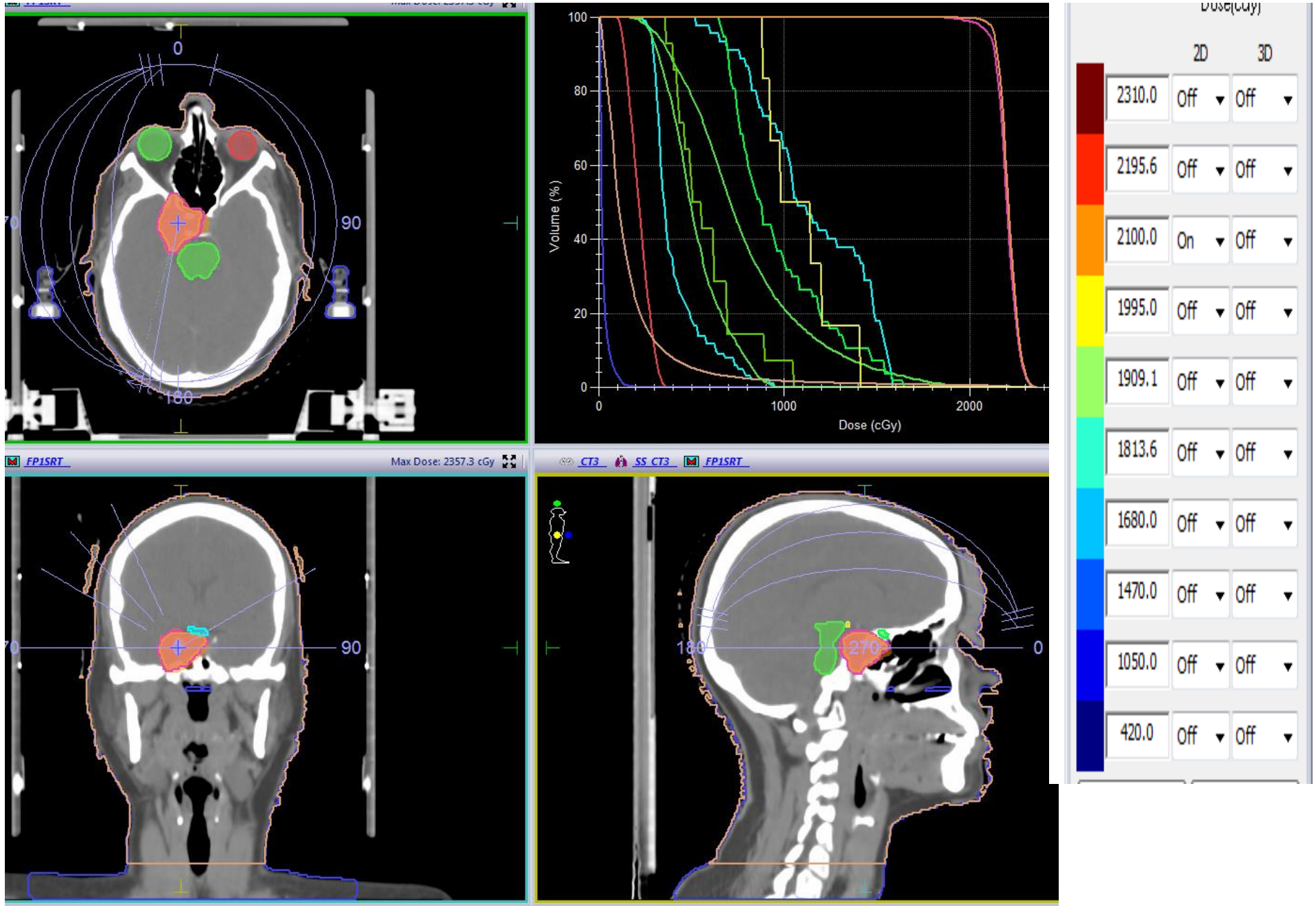
→20% and 5% (not much reviling)



Typical example :Dose Distribution: VMAT



Typical example :Dose Distribution: VMAT



OAR Doses

Two Main references – Both Published in 2010

MEDICAL PHYSICS
The International Journal of Medical Physics Research and Practice

Task group report | Free Access

Stereotactic body radiation therapy: The report of AAPM Task Group 101

Correction(s) for this article

ELSEVIER

International Journal of Radiation Oncology*Biology*Physics
Volume 76, Issue 3, Supplement, 1 March 2010, Pages S10-S19

Introductory Paper

Use of Normal Tissue Complication Probability Models in the Clinic

Lawrence B. Marks M.D. *, Ellen D. Yorke Ph.D. †, Andrew Jackson Ph.D. †, Randall K. Ten Haken Ph.D.

QUANTEC- OAR Doses

Table 1. QUANTEC Summary: Approximate Dose/Volume/Outcome Data for Several Organs Following Conventional Fractionation (Unless Otherwise Noted)*

Organ	Volume segmented	Irradiation type (partial organ unless otherwise stated)†	Endpoint	Dose (Gy), or dose/volume parameters†	Rate (%)	Notes on dose/volume parameters
Brain						
	Whole organ	SRS (single fraction)	Symptomatic necrosis	V12 <5–10 cc	<20	Rapid rise when V12 > 5–10 cc
Brain stem						
	Whole organ	SRS (single fraction)	Permanent cranial neuropathy or necrosis	Dmax <12.5	<5	For patients with acoustic tumors
Optic nerve / chiasm						
	Whole organ	SRS (single fraction)	Optic neuropathy	Dmax <12	<10	
Spinal cord						
	Partial organ	SRS (single fraction)	Myelopathy	Dmax = 13	1	Partial cord cross-section irradiated
	Partial organ	SRS (hypofraction)	Myelopathy	Dmax = 20	1	3 fractions, partial cord cross-section irradiated
Cochlea						
	Whole organ	SRS (single fraction)	Sensory neural hearing loss	Prescription dose ≤14	<25	Serviceable hearing

TG-101

a dose equal or greater than the indicated threshold dose for the given number of fractions used. For parallel tissue, the volume-dose constraints are based on a critical minimum volume of tissue that should receive a dose equal to or less than the indicated threshold dose for the given number of fractions used.

		One fraction		Three fractions		Five fractions		
Serial tissue	Max critical volume above threshold	Threshold dose (Gy)	Max point dose (Gy)[a]	Threshold dose (Gy)	Max point dose (Gy)[a]	Threshold dose (Gy)	Max point dose (Gy)[a]	End point (≥Grade3)
Optic pathway	<0.2 cc	8	10	15.3 (5.1 Gy/fx)	17.4 (5.8 Gy/fx)	23 (4.6 Gy/fx)	25 (5 Gy/fx)	Neuritis
Cochlea			9		17.1 (5.7 Gy/fx)		25 (5 Gy/fx)	Hearing loss
Brainstem (not medulla)	<0.5 cc	10	15	18 (6 Gy/fx)	23.1 (7.7 Gy/fx)	23 (4.6 Gy/fx)	31 (6.2 Gy/fx)	Cranial neuropathy
Spinal cord	<0.35 cc	10	14	18 (6 Gy/fx)	21.9 (7.3 Gy/fx)	23 (4.6 Gy/fx)	30 (6 Gy/fx)	Myelitis
and medulla	<1.2 cc	7		12.3 (4.1 Gy/fx)		14.5 (2.9 Gy/fx)		
Spinal cord subvolume								

QUANTEC- Issue

Table 1. QUANTEC Summary: Approximate Dose/Volume/Outcome Data for Several Organs Following Conventional Fra… …herwise Noted)*

Organ	Volume segmented	Irradiation type (partial organ unless otherwise stated)†	Endpoint	Dose (G…		Notes on …/volume parameters
Brain						
	Whole organ	SRS (sin…				V12 > 5–10 cc
Brain stem						
					<5	For patients with acoustic tumors
Optic nerve / chiasm						
	W…		…ropathy	Dmax <12	<10	
Spinal cord						
	Partial c…	SRS (single fraction)	Myelopathy	Dmax = 13	1	Partial cord cross-section irradiated
	Partial or…	SRS (hypofraction)	Myelopathy	Dmax = 20	1	3 fractions, partial cord cross-section irradiated
Cochlea						
	Whole organ	SRS (single fraction)	Sensory neural hearing loss	Prescription dose ≤14	<25	Serviceable hearing

Consider only non-intensity modulated dose distribution –

Consider only 1#SRS→ No Solution for >3# and 5# prescription

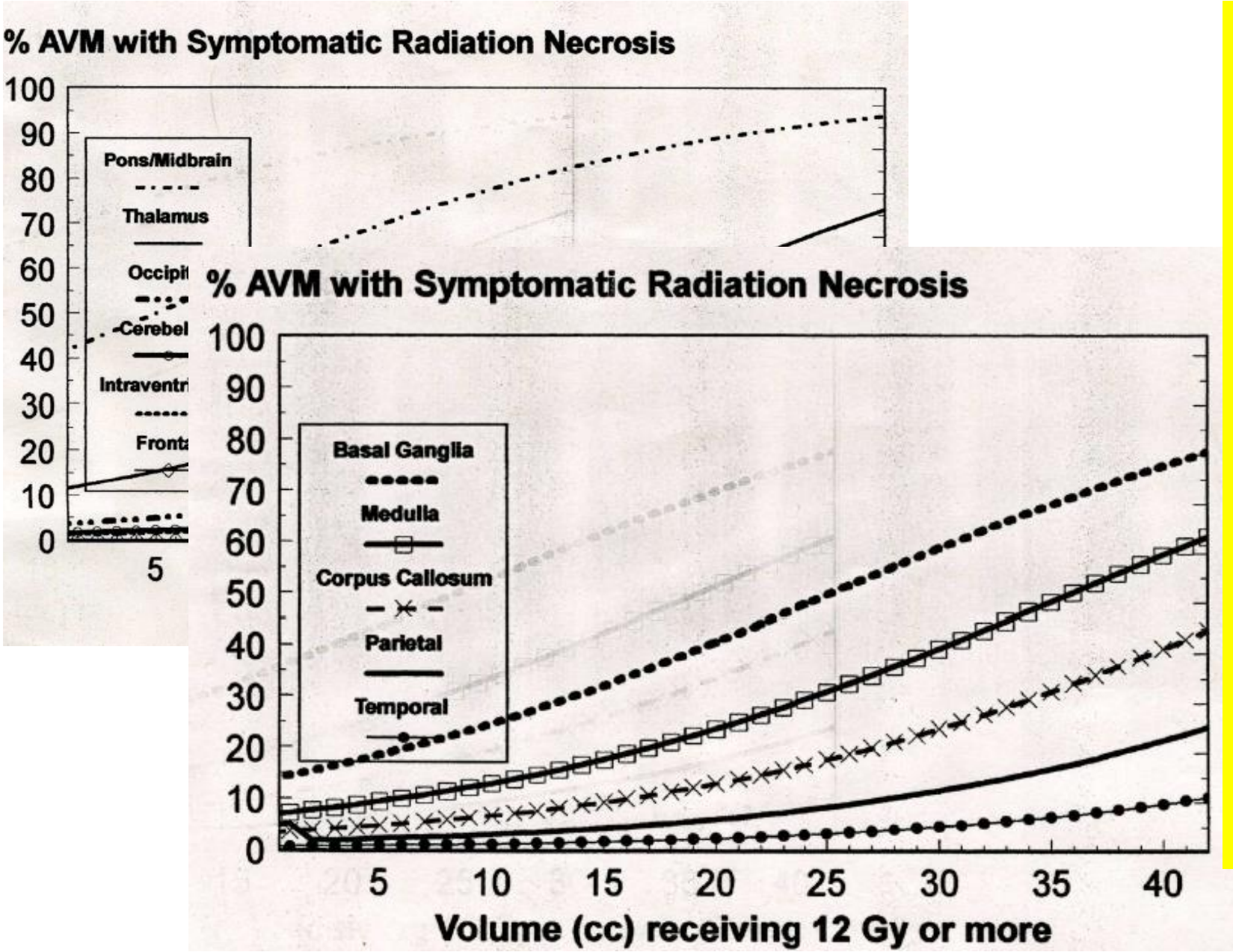
TG101- Issues

Serial tissue	Max critical volume above threshold	One fraction		Three fractions		Five fractions	
		Threshold dose (Gy)	Max point dose			't dose	Max point dose (Gy)[a]
Optic pathway	<0.2						25 (5 Gy/fx)
Cochlea							25 (5 Gy/fx)
Brainstem (not medulla)				18 (6 Gy/fx)	23.1 (7.7 Gy/fx)	23 (4.6 Gy/fx)	31 (6.2 Gy/fx)
Spinal cord and medulla			14	18 (6 Gy/fx)	21.9 (7.3 Gy/fx)	23 (4.6 Gy/fx)	30 (6 Gy/fx)
		7		12.3 (4.1 Gy/fx)		14.5 (2.9 Gy/fx)	

Not biased to intensity modulated or unmodulated techniques

Have a solution for both 1# and 1-5# as well

Flickinger Table: For brain Necrosis >12 Gy



Necrosis is undesirable but unavoidable phenomenon

Take Home Msg: OAR doses

OAR Unchallenged Category

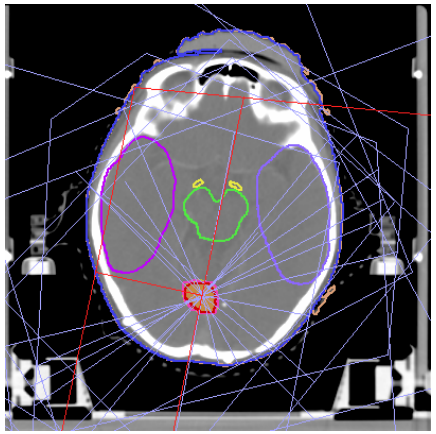
Around 50% cases SRS tumour will be isolated at a 2 cm distance from Optic pathway ,Brainstem and cochlea –Only OAR normal Brain

OAR Challenged Category (not touched)

Possible to achieve the desired dose to OAR with a little try. No Dose compromise to the PTV required.

OAR Invaded Category:

Difficult to achieve the desired dose to –OAR , often required coverage compromise to PTV



OAR s	
Brainstem	A Must Save (if they are working)
Optic pathway	
Cochlea(s)	
Mastoid	Essential but absolute- Can be reduce as much as possible
Eyes	
Lenses	
Temporal lobes	
Uninvolved Brain	

Dose fall-off characteristics

Take Home Msg on Dose fall off

Max fall off ≈ 12%/ mm

Mean fall off between 100%-80%= 8%/mm

Mean fall off between 100%-50%= 5.5%/mm

Mean fall off between 100%-20%= 4.4%/mm

Fixed beam 3DCRT/IMRT Shows slightly higher dose fall off than VMAT plans*

Remember- You may not be able change the plan for getting a better gradient -

- Thanks a lot.