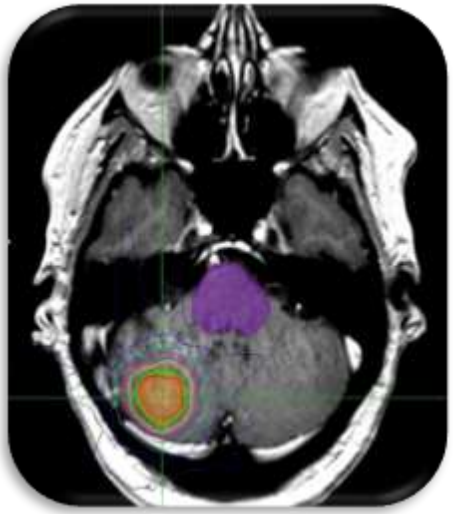
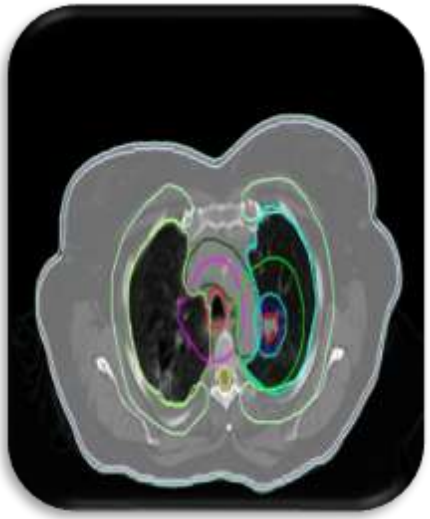
SRS AND SBRT- THE WORKFLOW





DR KANHU CHARAN PATRO

MD,DNB(Radiation Oncology),FICRO,FAROI(USA), MBA, PDCR,CEPC

HOD-Radiation Oncology.

ISRo - Institute of Stereotactic Radiation oncology

Mahatma Gandhi Cancer Hospital & Research Institute, Visakhapatnam

(drkanhupatro.com) drkcpatro@gmail.com M-9160470564

WHAT IS SRS/SBRT?

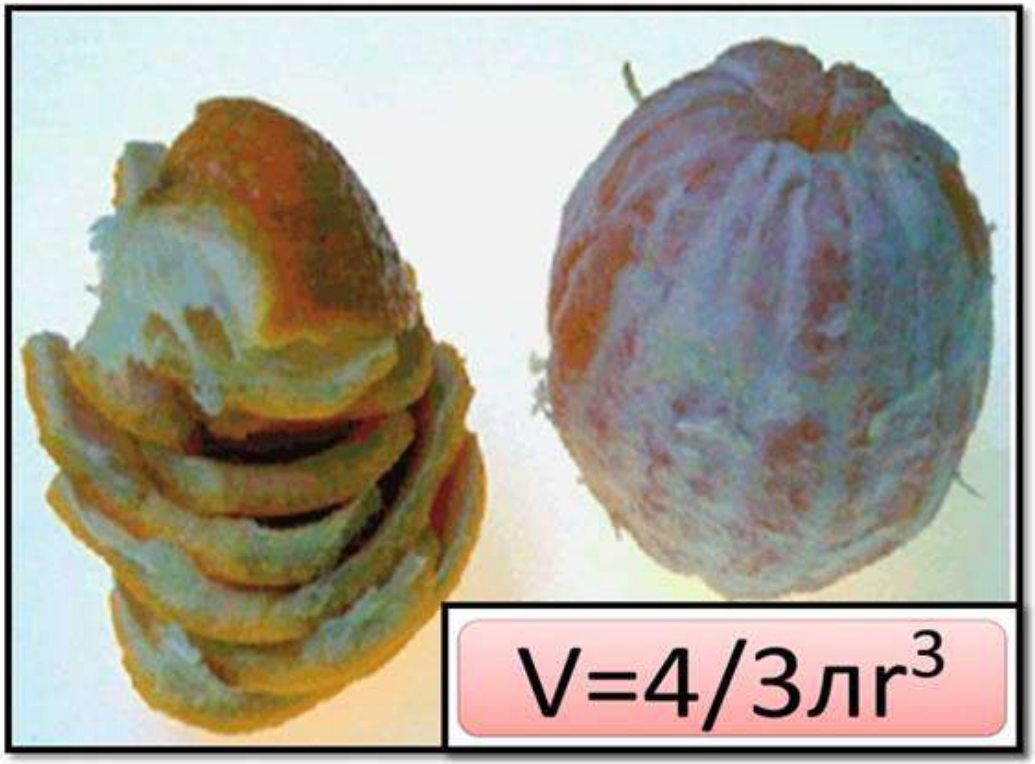
- Stereotactic radiosurgery (**SRS**) uses **many precisely focused radiation beams** to treat tumors and other problems in the brain, neck, lungs, liver, spine and other parts of the body.
- It is not surgery in the traditional sense because there's no incision.
- SRS is for cranial
- SBRT for extracranial

The duo

- High dose
- Strict immobilization

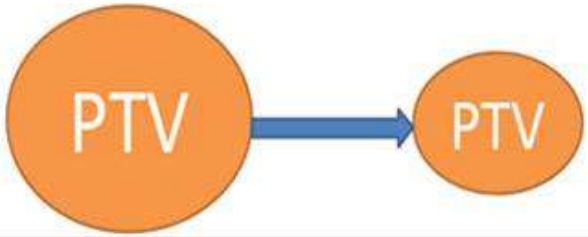
Errors

THE ORANGE PEEL CONCEPT



REDUCTION IN PTV

- Custom immobilization
- Respiratory management
- Image guidance



Orange and its peel representing a target volume and its margin. A 6.5 mm thick margin (peel) consists of the same volume as a 5 cm diameter target (orange)

verellen et al /2007

2nd NOV 2018/PHYSICS

The wide spectrum

Cranial

- Metastasis
  - De novo
  - After WBRT
- Arteriovenous malformation
- Vestibular schwannoma
- Reirradiation glioma
- Glomus jugularae
- Hamartoma
- Cavernoma
- Meningioma
- Trigeminal neuralgia
- Tremor
- Epilepsy

Extracranial

- Bone metastasis
- Prostate
- Lung primary/ metastasis
- Pancreas
- Adrenal metastasis
- Liver metastasis/HCC
- Spine metastasis
- Nodal recurrence
- Head and neck reirradiation

SRS/SBRT PROTOCOLS-SITE WISE

SITE	PROTOCOL
➢ BRAIN METS	➢ RTOG 9508 ➢ JROSG 99-1
➢ BRAIN RERT	➢ RTOG 9005
➢ HEAD & NECK	➢ MIRI PROTOCOL
➢ SPINE	➢ RTOG 0631
➢ LUNG CENTRAL	➢ RTOG 0813
➢ LUNG PERIPHERAL	➢ RTOG 0915
➢ LIVER-HCC	➢ RTOG1112
➢ LIVER METS	➢ RTOG 0438
➢ PANCREAS	➢ ALLIANCE
➢ PROSTATE	➢ PRIME [TMH] ➢ ONE SH0T

CLINICAL TRIAL.GOV

26th APRIL 2019/STEREOTAXY

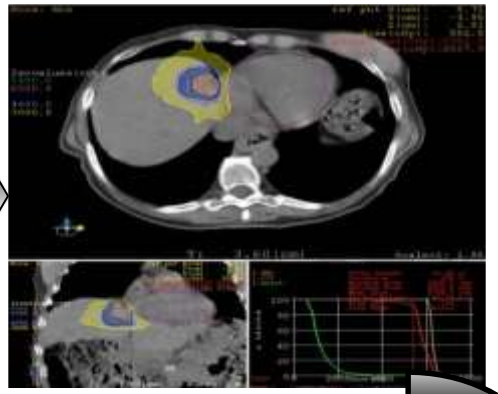
WHAT are the requirements?

- Micro MLC/cone
- Planning system
- Imaging
- Immobilization
- Respiratory Motion management system
- QA accessories
- CBCT
- Protocols

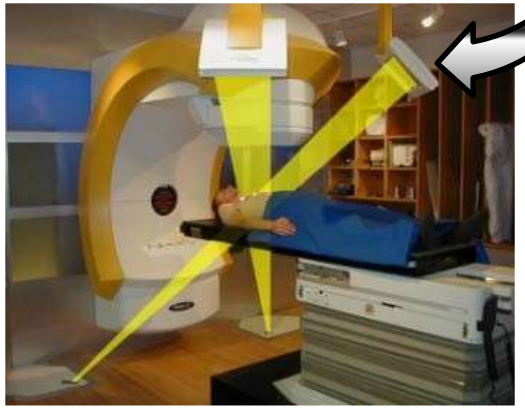
SBRT WORKFLOW

Simulation

Motion Management



Planning

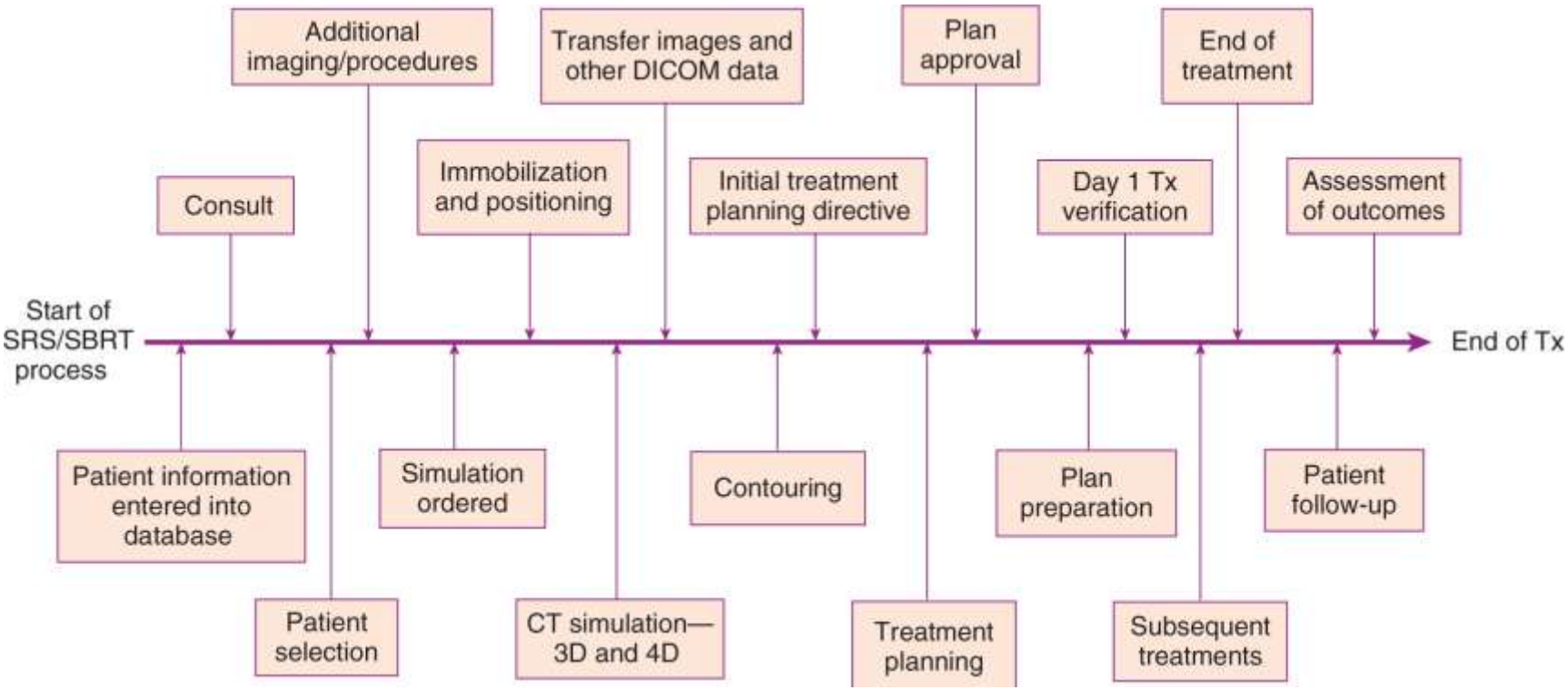


Localization

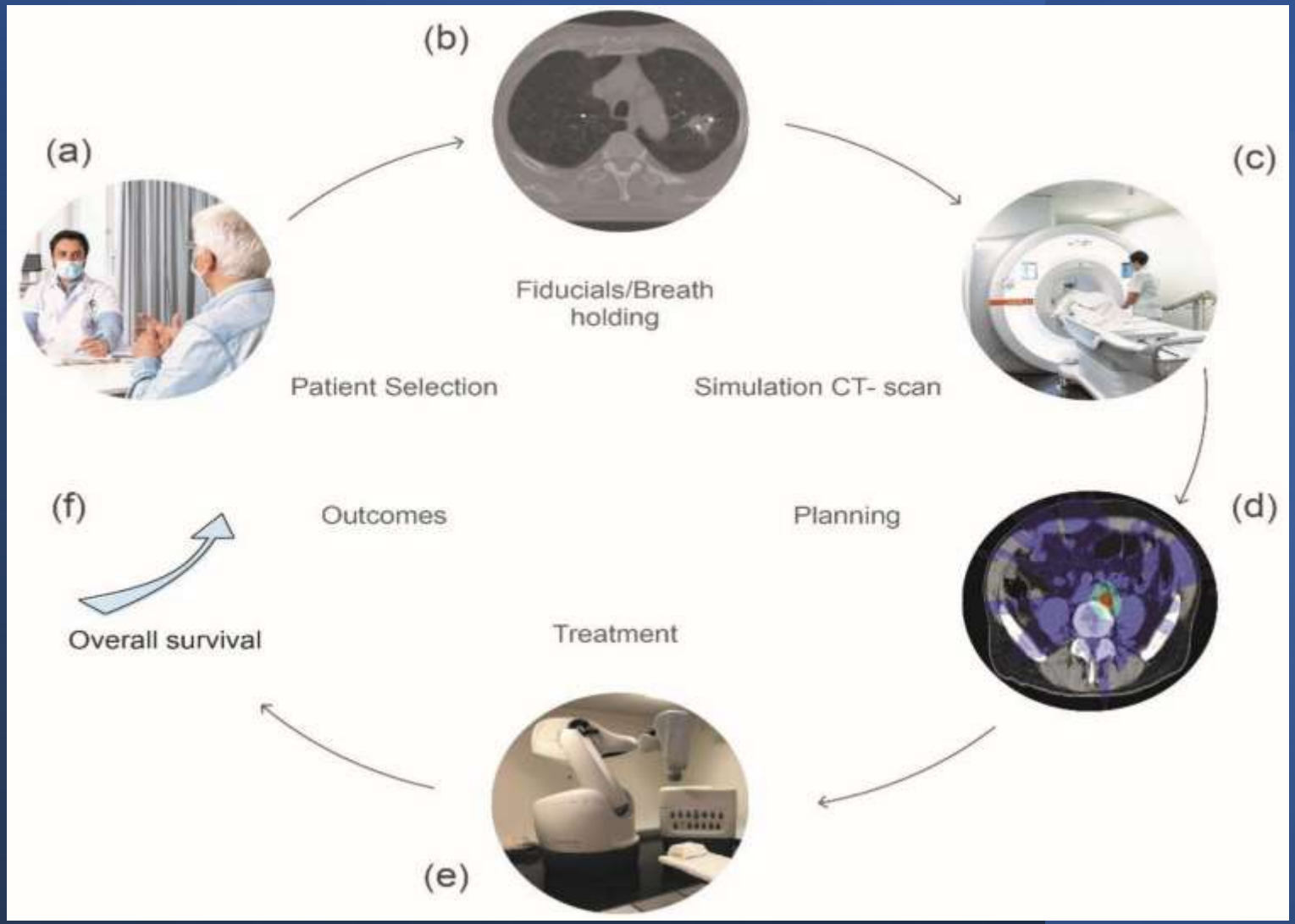
Motion Verification

Delivery

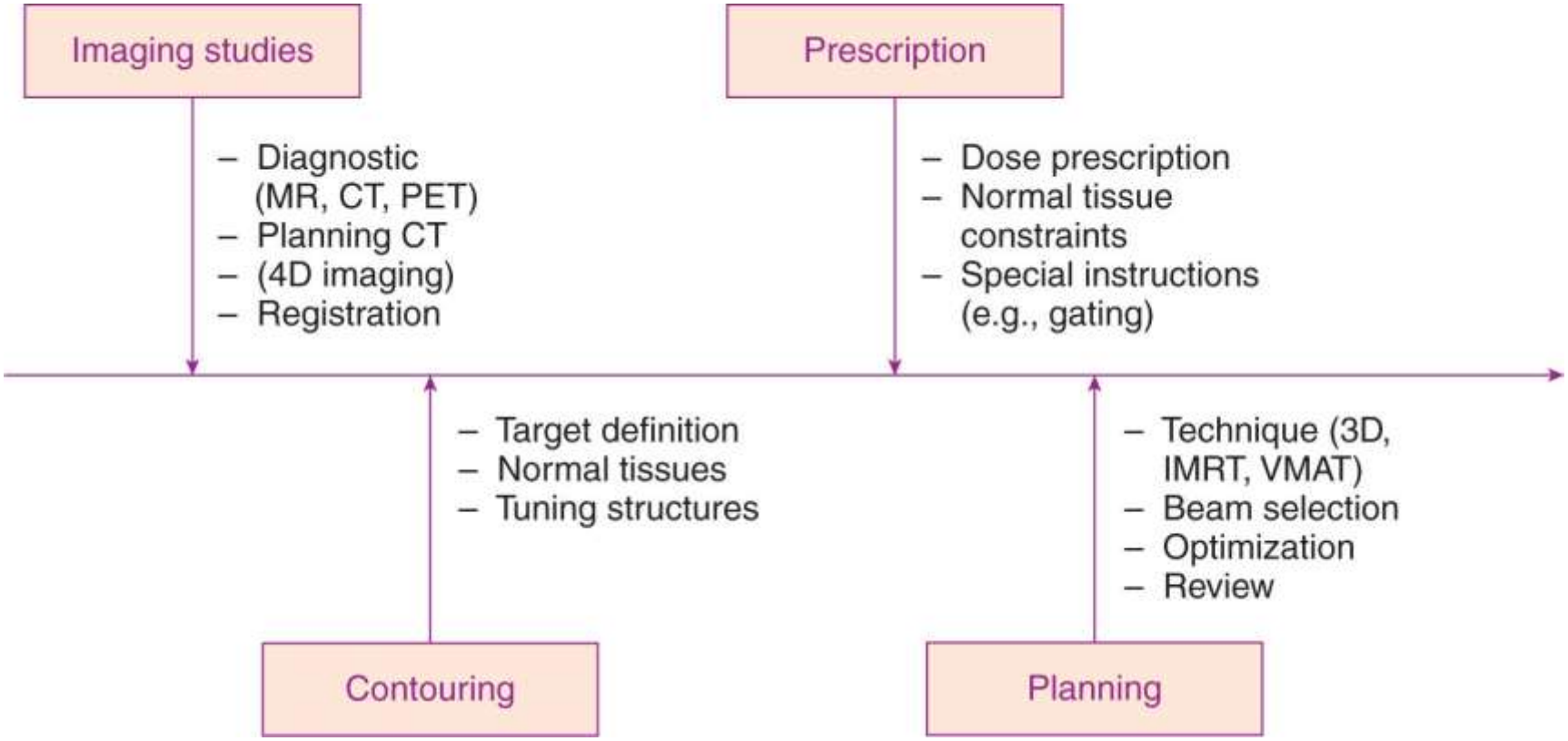
Steps


Start of SRS/SBRT process
End of Tx
Consult
Additional imaging/procedures
Immobilization and positioning
Transfer images and other DICOM data
Initial treatment planning directive
Plan approval
Day 1 Tx verification
End of treatment
Assessment of outcomes
Patient information entered into database
Patient selection
Simulation ordered
CT simulation—3D and 4D
Contouring
Treatment planning
Plan preparation
Subsequent treatments
Patient follow-up

Steps SBRT

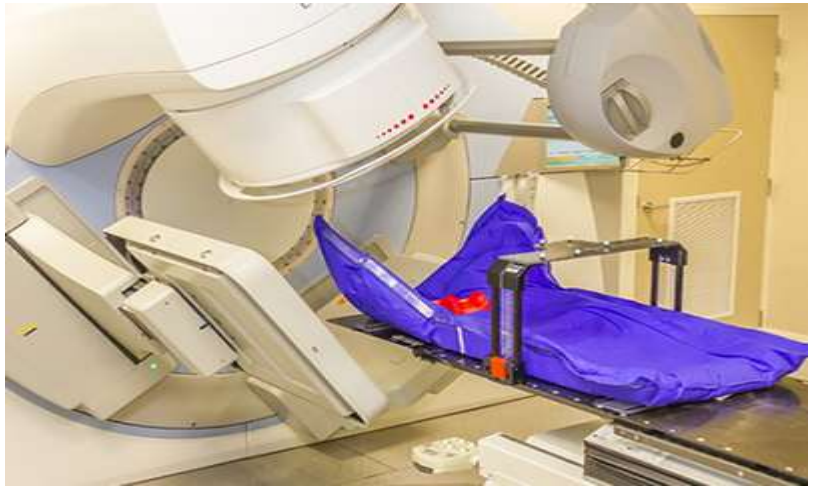

(a)
Patient Selection
(b)
Fiducials/Breath holding
(c)
Simulation CT- scan
(d)
Planning
(e)
Treatment
(f)
Outcomes
Overall survival

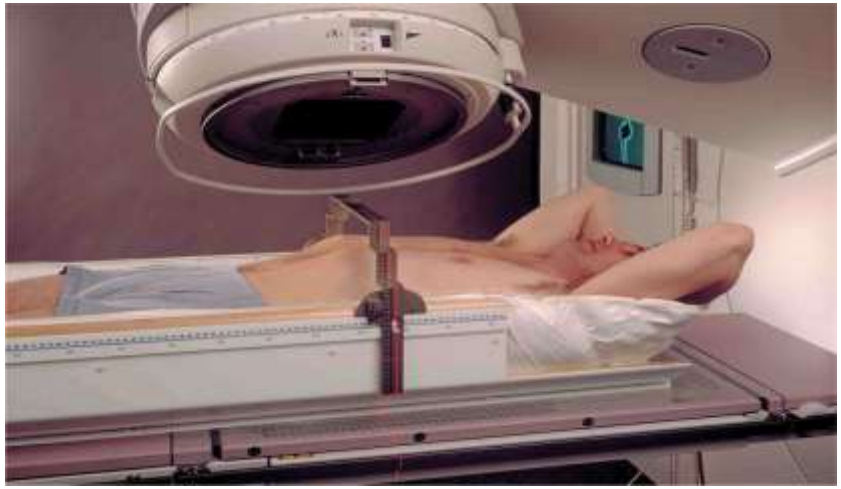
Steps


Imaging studies
– Diagnostic (MR, CT, PET)
– Planning CT
– (4D imaging)
– Registration
Prescription
– Dose prescription
– Normal tissue constraints
– Special instructions (e.g., gating)
Contouring
– Target definition
– Normal tissues
– Tuning structures
Planning
– Technique (3D, IMRT, VMAT)
– Beam selection
– Optimization
– Review

SRS – Immobilization –frame to frameless

SBRT – Immobilization





Motion management not required

- Brain
- Head and neck
- Lymph node
- Prostate
- Spine
- Extremity bone

Motion management required

- Lung
- RIB
- Adrenal
- Liver
- PVTT
- Pancreas
- CBD

Hepatopancreatic biliary

Everybody is a king when everything is inside the ring [PTV]

BECAUSE ORGANS DO NOT FOLLOW STATUE GAME

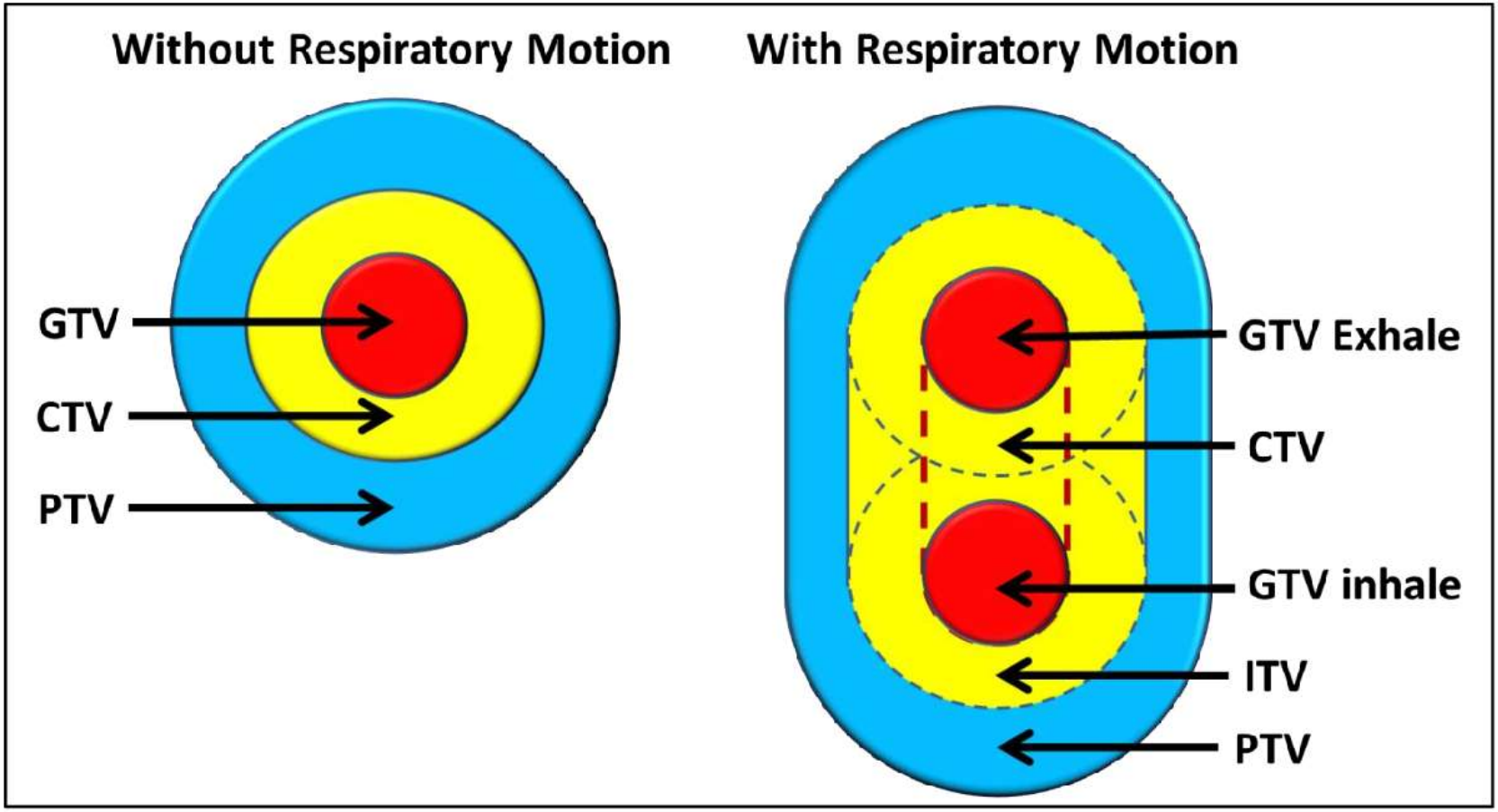
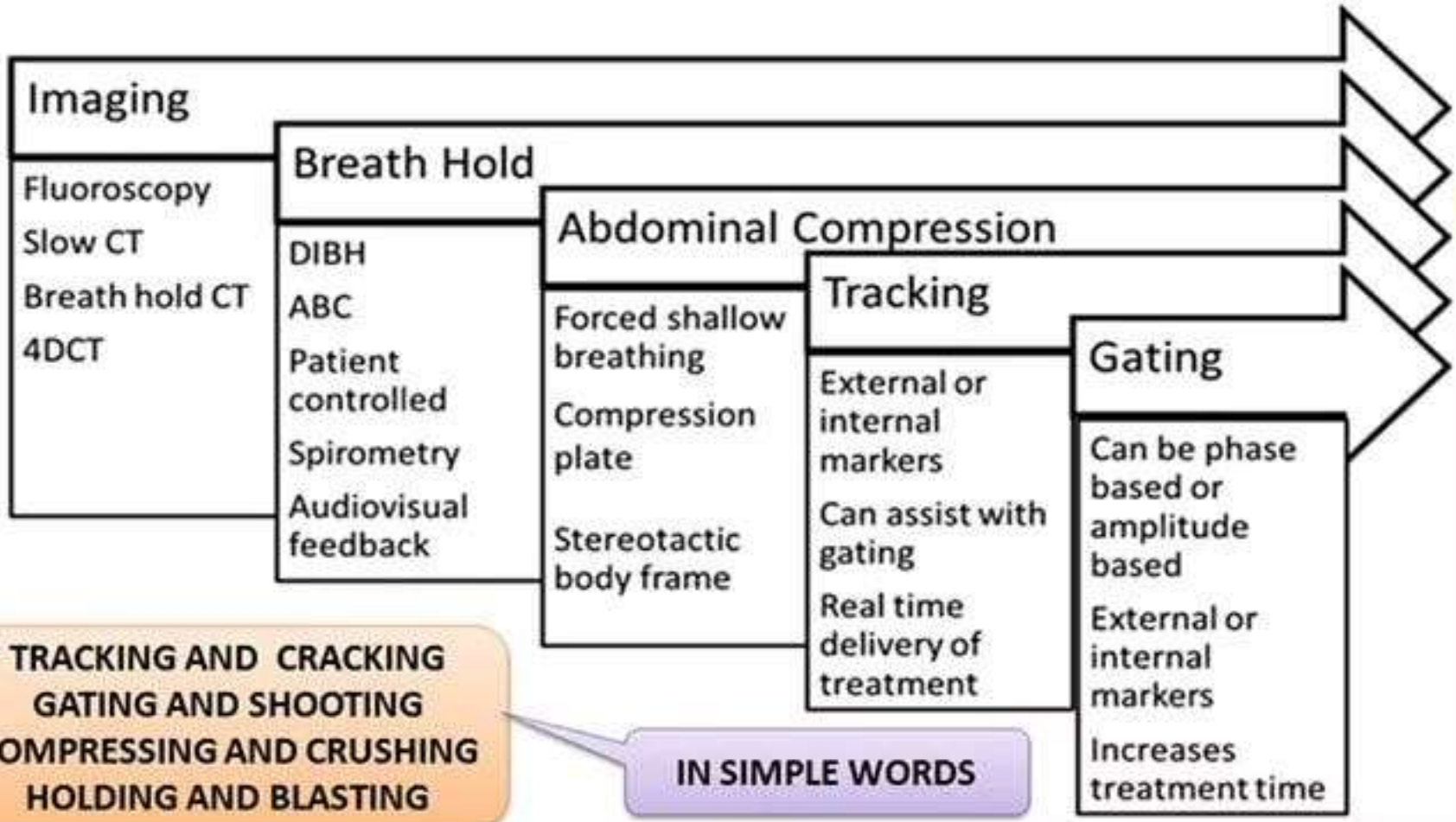


Figure 1-10: Illustration of gross tumor volume (GTV) expansion to clinical target volume (CTV),

MOTION MANAGEMENT IN RADIATION



TRACKING AND CRACKING
GATING AND SHOOTING
COMPRESSING AND CRUSHING
HOLDING AND BLASTING

IN SIMPLE WORDS

A J COLE/CLINICAL ONCOLOGY/2014

1st NOV 2018/PHYSICS

ONCOLOGY EDUCATIVE CARTOON/SLIDE -BY DR KANHU CHARAN PATRO, IMAGES & DATA- GOOGLE

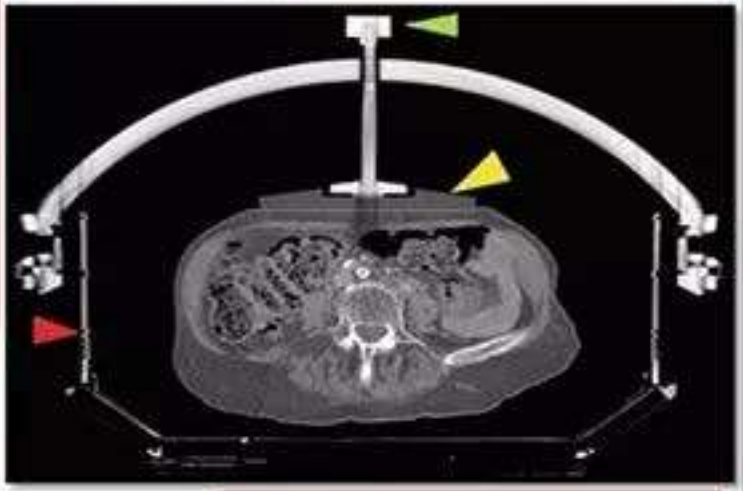
Various Motion management systems

- Varian RPM – gating and breath hold
- Elekta Active Breath Control
- Accuray Cyberknife Synchrony
- Novalis Brainlab ExacTrac
- Phillips Bellows system
- Anzai belt
- Calypso beacons
- Abdominal Compression
  - Elekta body frame
  - CIVCO Body Frame
  - Medical Intelligence BodyFix

Abdominal compression

MOTION M_X- ABDOMINAL COMPRESSION

1. Abdominal compression plate can be used in conjunction with stereotactic frames to limit diaphragmatic motion by forced shallow breathing.
2. Permits normal respiration while reducing diaphragmatic and hence tumor motion.
3. May be unsuitable for obese patients or those with poor respiratory function. Can lead to more erratic breathing in some instances.
4. Requires regular imaging due to difficulties associated with plate position reproducibility



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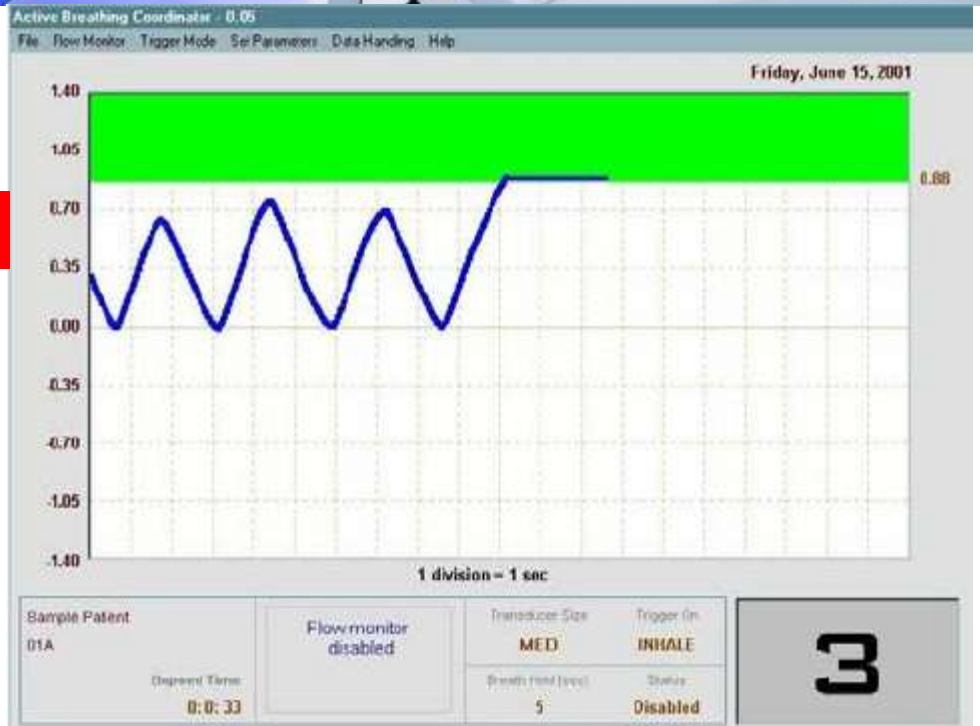
3rd NOV 2018/PHYSICS

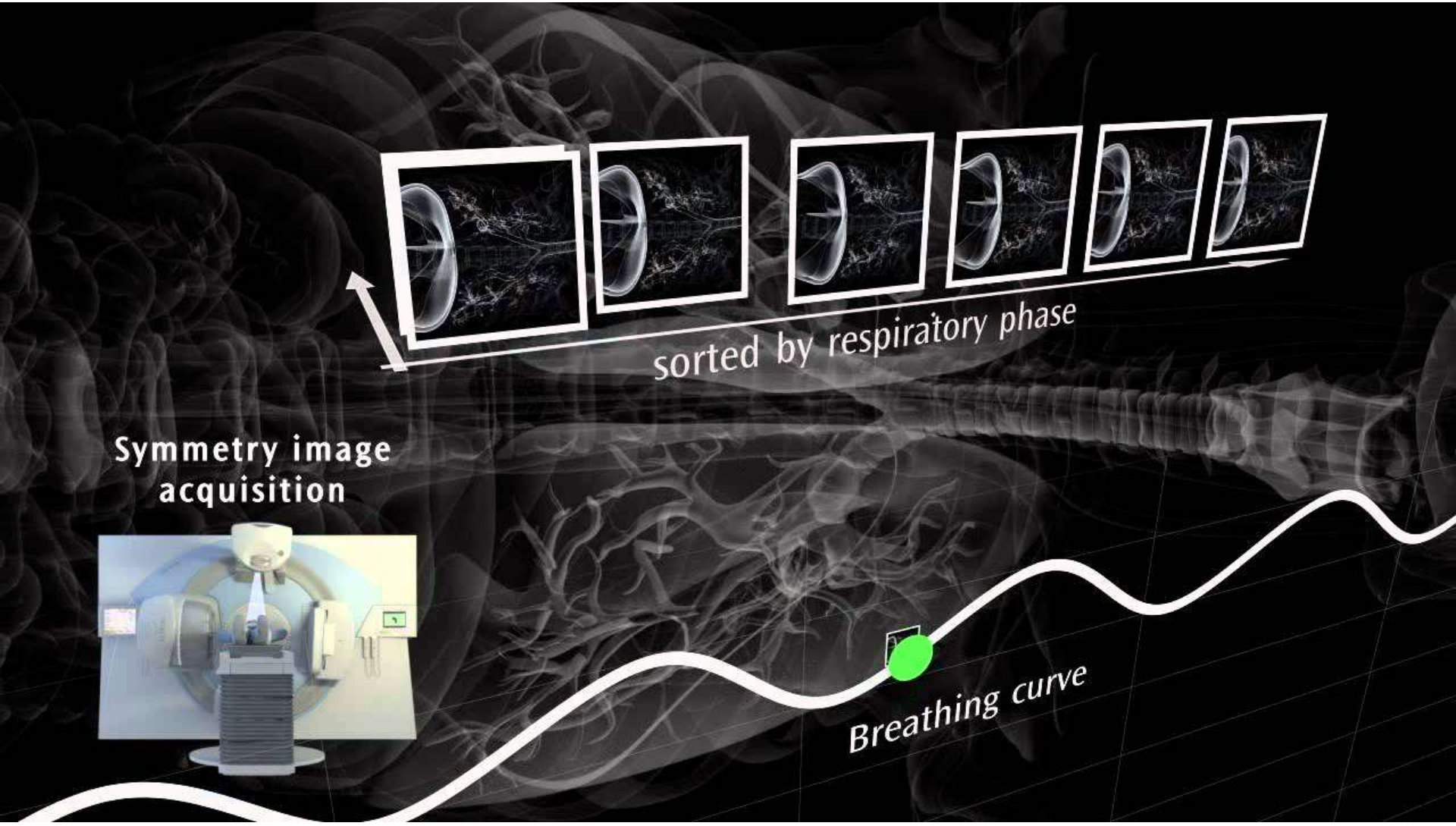

Versa HD


24

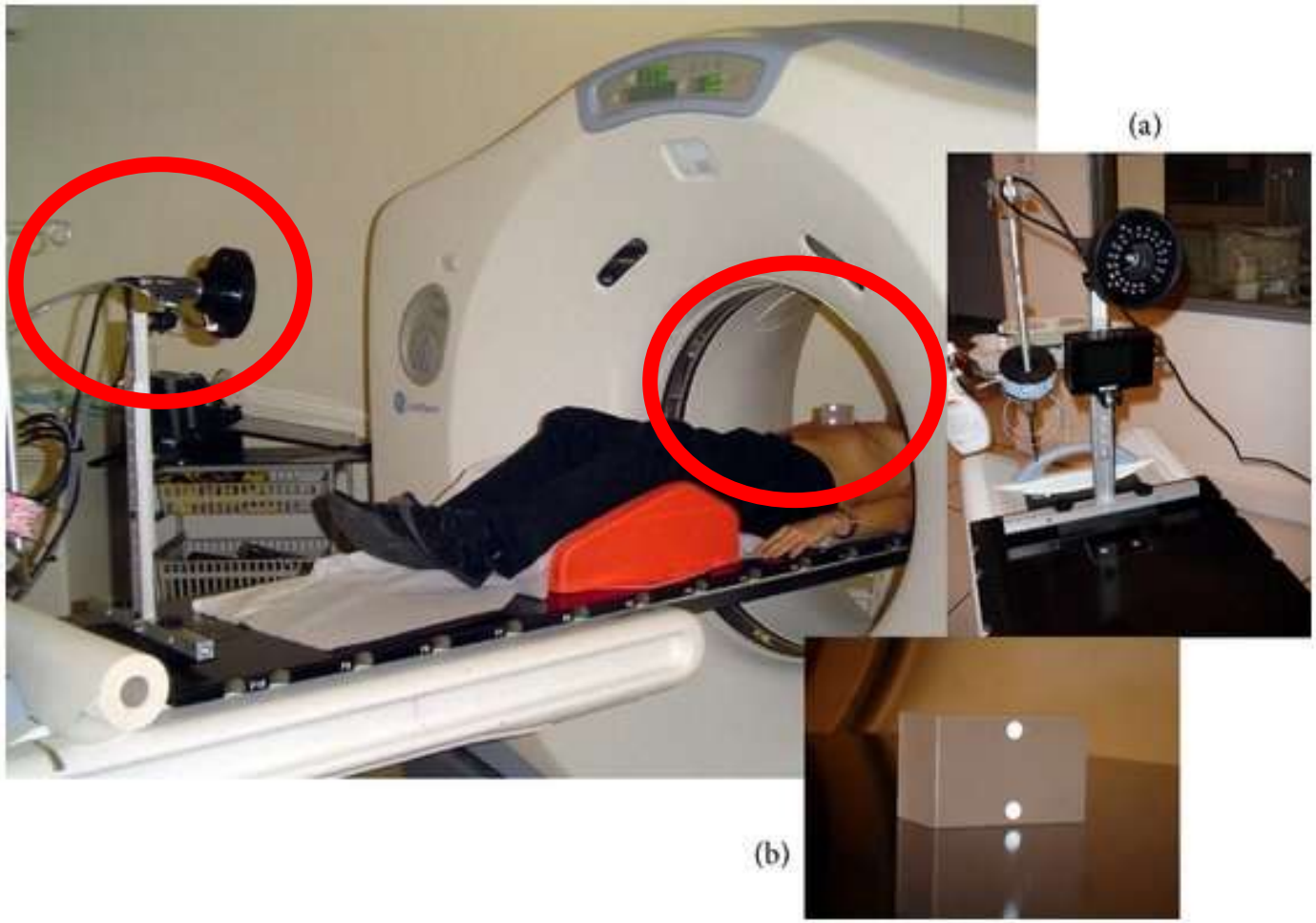
Elekta ABC


Active Breathing Coordinator - 0.05
File
Flow Monitor
Trigger Mode
Set Parameters
Data Handling
Help
Friday, June 15, 2001
1.40
1.05
0.70
0.35
0.00
-0.35
-0.70
-1.05
-1.40
0.88
1 division = 1 sec
Sample Patient
01A
Flow monitor disabled
Transducer Size
MED
Trigger On
INHALE
0:0:33
5
Disabled
3

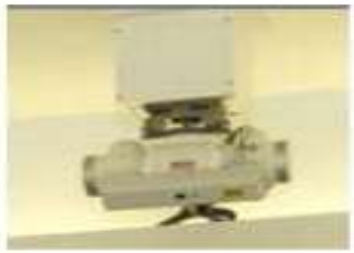
Elekta symmetry for ITV generation



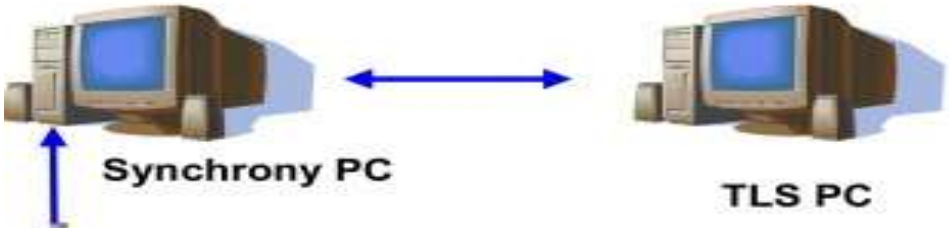
Varian RPM gating



CyberKnife with Synchrony™



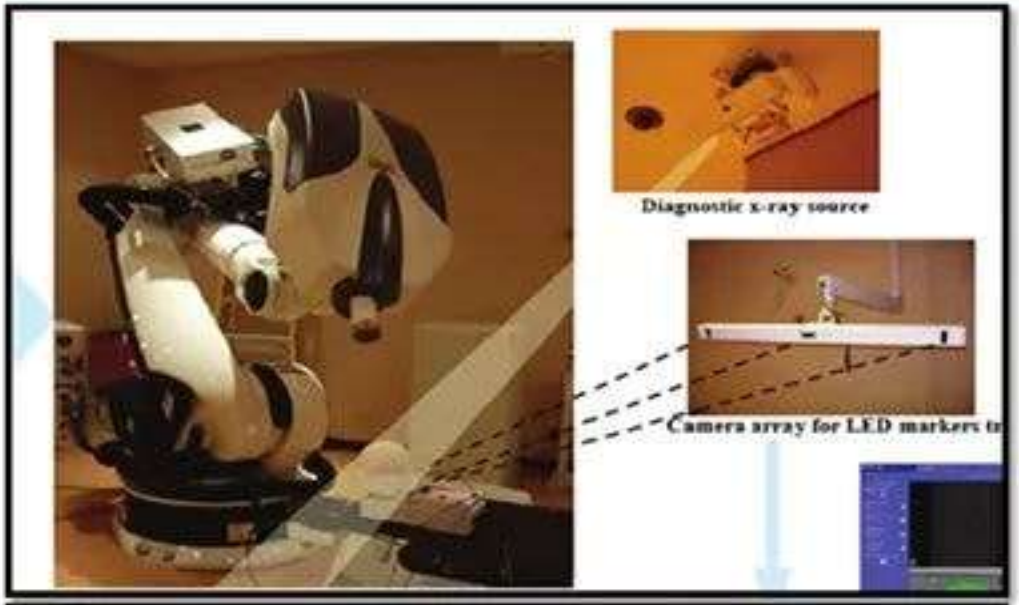
Diagnostic x-ray source



Synchrony PC

TLS PC

CYBER KNIFE X-RAY BASED TRACKING

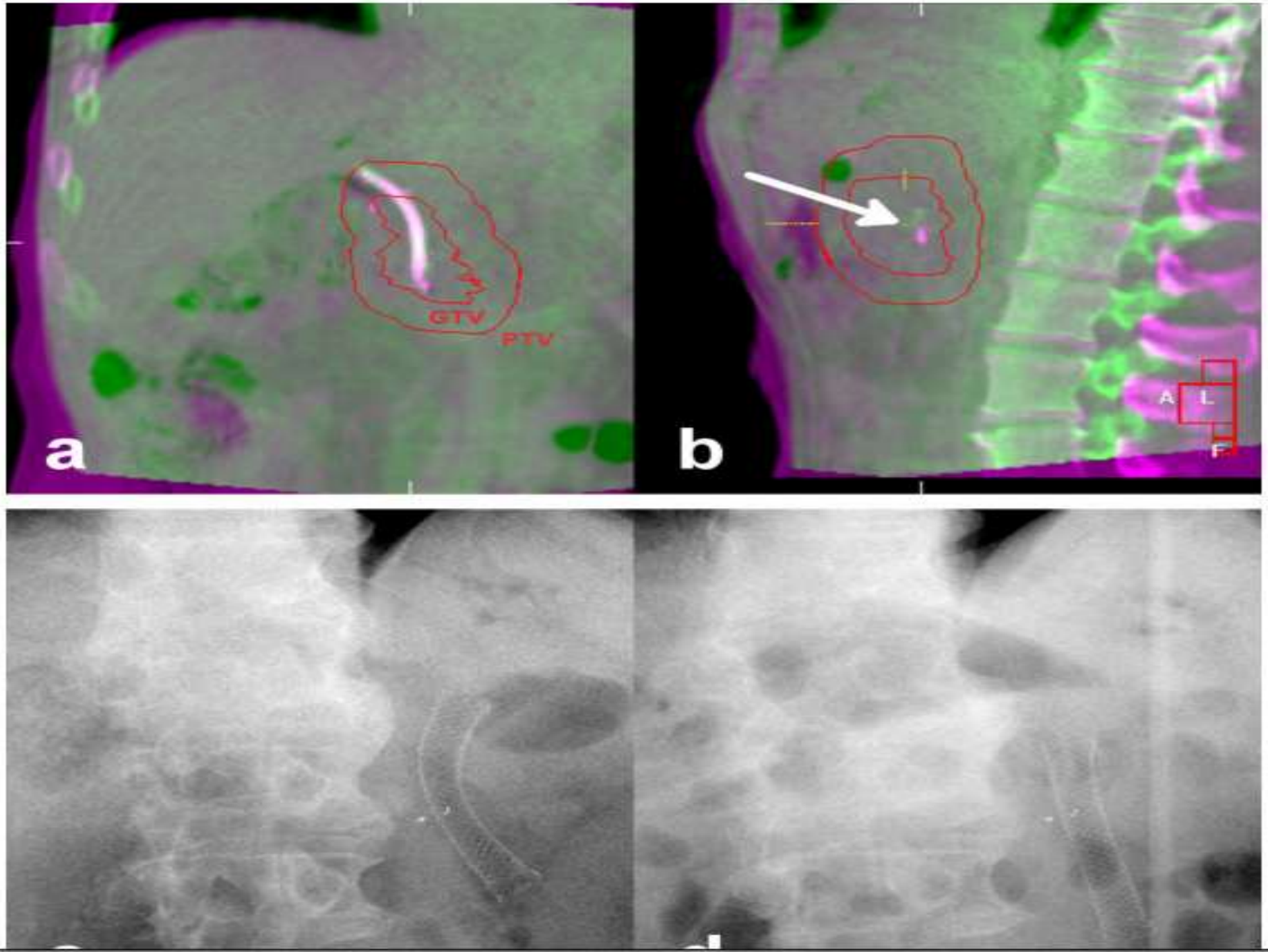


1. X ray based
2. Fiduciary based
3. Roof mounted X ray tube
4. Roof mounted detector
5. Intra-fractional tumor motion during treatment delivery, regardless of the couch angle or gantry position
6. Monitoring throughout the entire treatment
7. Precise image fusion based on bony anatomy
8. Immediate alert to the user in case of deviations
9. Automatic marker detection offers clinical consistency

A J COLE/CLINICAL ONCOLOGY/2014

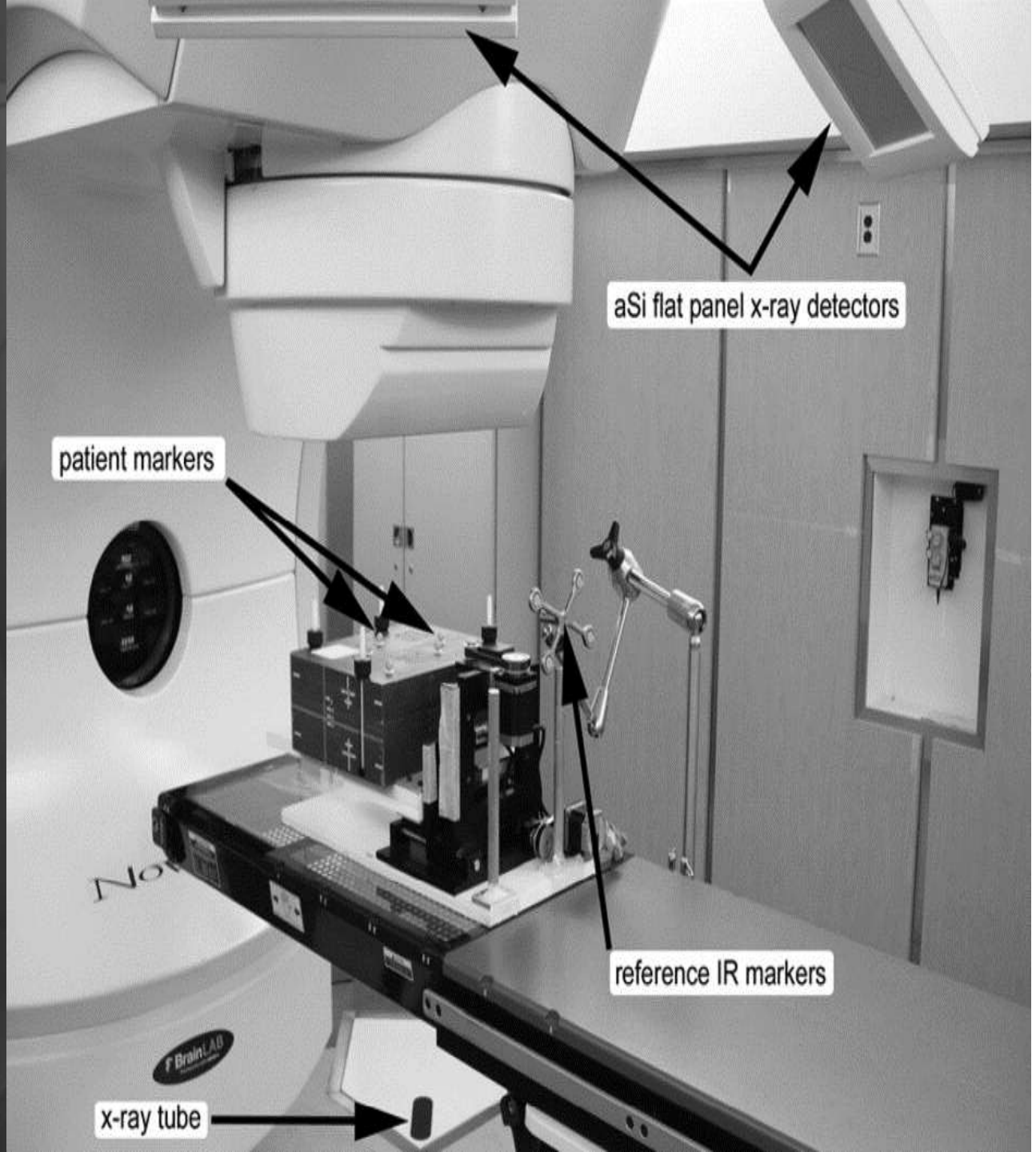
18th NOV 2018/PHYSICS

ONCOLOGY EDUCATIVE CARTOON/SLIDE -BY DR KANHU CHARAN PATRO, IMAGES & DATA- GOOGLE


GTV
PTV
a
b
A
L
F

ExacTrac Dynamic®

CBCT positioning with ExacTrac monitoring



Other Commercially available Tracking Systems

- AlignRT – Vision RT (Surface Guided)
- RTRT System
- VERO System
- Exac-Trac System
- Calypso system






Table 2
Summary of advantages and disadvantages of motion management techniques

	General description	Advantages	Disadvantages
Slow computed tomography	Computed tomography scan operated slowly and/or multiple slices taken are averaged, i.e. multiple phases of respiration are recorded by slice.	Generally available on most computed tomography scanners.	Loss of resolution, which may lead to tumour blurring and subsequent increase in observer error in tumour and OAR delineation.
Four-dimensional computed tomography	Enables correlation of computed tomography scanning with patient's respiration. Breathing cycle monitored by using external surrogate.	Reduced blurring/artefact compared with slow computed tomography. Can evaluate mean tumour position and tumour motion correlation with surrogates and surrounding OARs.	Increase in imaging dose compared with conventional computed tomography scan. May be unreliable in irregular breathing patterns leading to artefact.
Deep inspiration breath-hold	Patient attempts a maximum reproducible inhalation during simulation and treatment. Audio-visual coaching may assist reproducibility.	Can potentially move a significant volume of lung tissue outside treatment field. Advantages over free-breathing are shorter time to deliver treatment, decreased tumour motion and decreased fluoroscopic imaging.	Simultaneous reduction in lung density associated with increase in lung volume may lead to overestimation of dosimetric coverage by certain treatment planning systems. May be limited by patient compliance.
Active breathing control	Assists breath-hold by use of a valved spirometer. Often at moderate or deep breath-hold.	Can reduce motion artefacts. Improvements in dose to organs at risk. Potential for dose escalation compared with free-breathing technique.	Patient selection important; non-compliance of patients with poor respiratory function. Increase in quality assurance procedures.
Abdominal compression	Abdominal compression plate can be used in conjunction with stereotactic frames to limit diaphragmatic motion by forced shallow breathing.	Permits normal respiration while reducing diaphragmatic and hence tumour motion.	May be unsuitable for obese patients or those with poor respiratory function. Can lead to more erratic breathing in some instances.Requires regular imaging due to difficulties associated with plate position reproducibility.
Gating	Delivery of radiation within a specified part of the patient's breathing cycle termed 'the gate'. Phase or amplitude based. Uses external respiration signals e.g. infrared, spirometry, thermistors or internal fiducials.	Can significantly reduce margins required, therefore potential decrease in dose to OARs. Imaging and treatment synchronised with patient's breathing cycle.	Increases time to deliver treatment. Assumes that fiducial signal and its periodicity is reflective of tumour motion. Requires regular imaging and therefore increased imaging dose.More complex quality assurance procedures.
Tracking	Real-time delivery of radiation with simultaneous tracking of internal or external surrogate.	Can significantly reduce margins required, therefore subsequent decrease in dose to OARs. Decreased time to deliver treatment compared to gating.	Increased imaging dose with fluoroscopy.

OAR, organ at risk

WHICH MOTION MANAGEMENT SYSTEM IS BETTER?

GOSSIP- WHOSE SPOUSE IS BETTER?

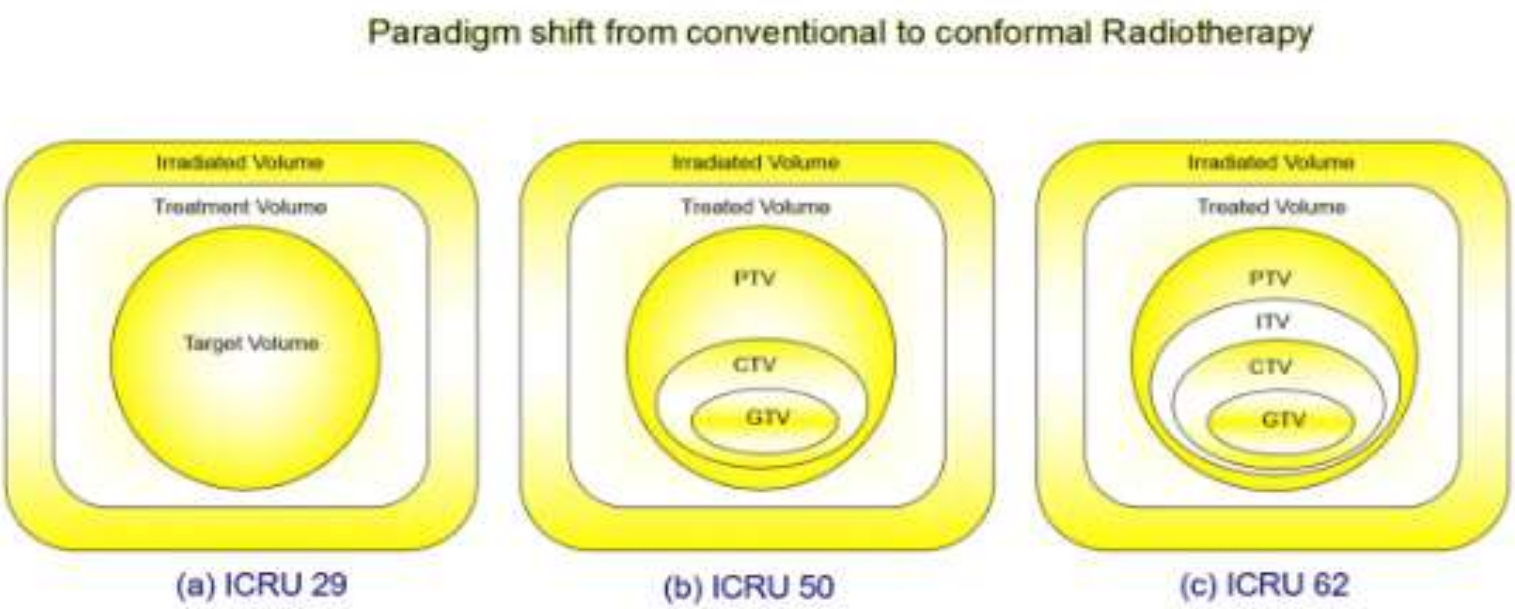
ANSWER- WHAT MANAGEMENT ACQUIRES

Managing the Management

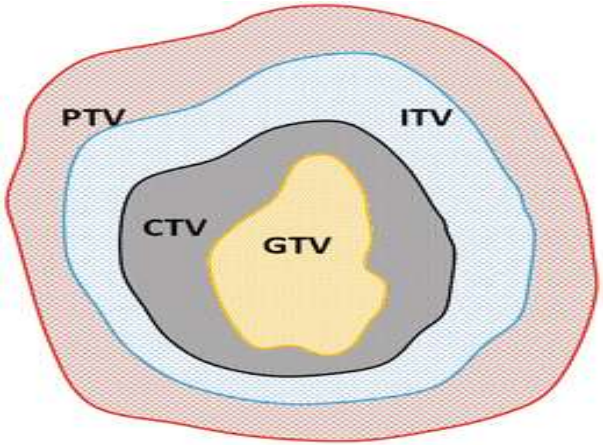

Charity
begins
at home


HOW TO DEAL
WITH YOUR
MOTHER
IN LAW

GTV-ITV-PTV

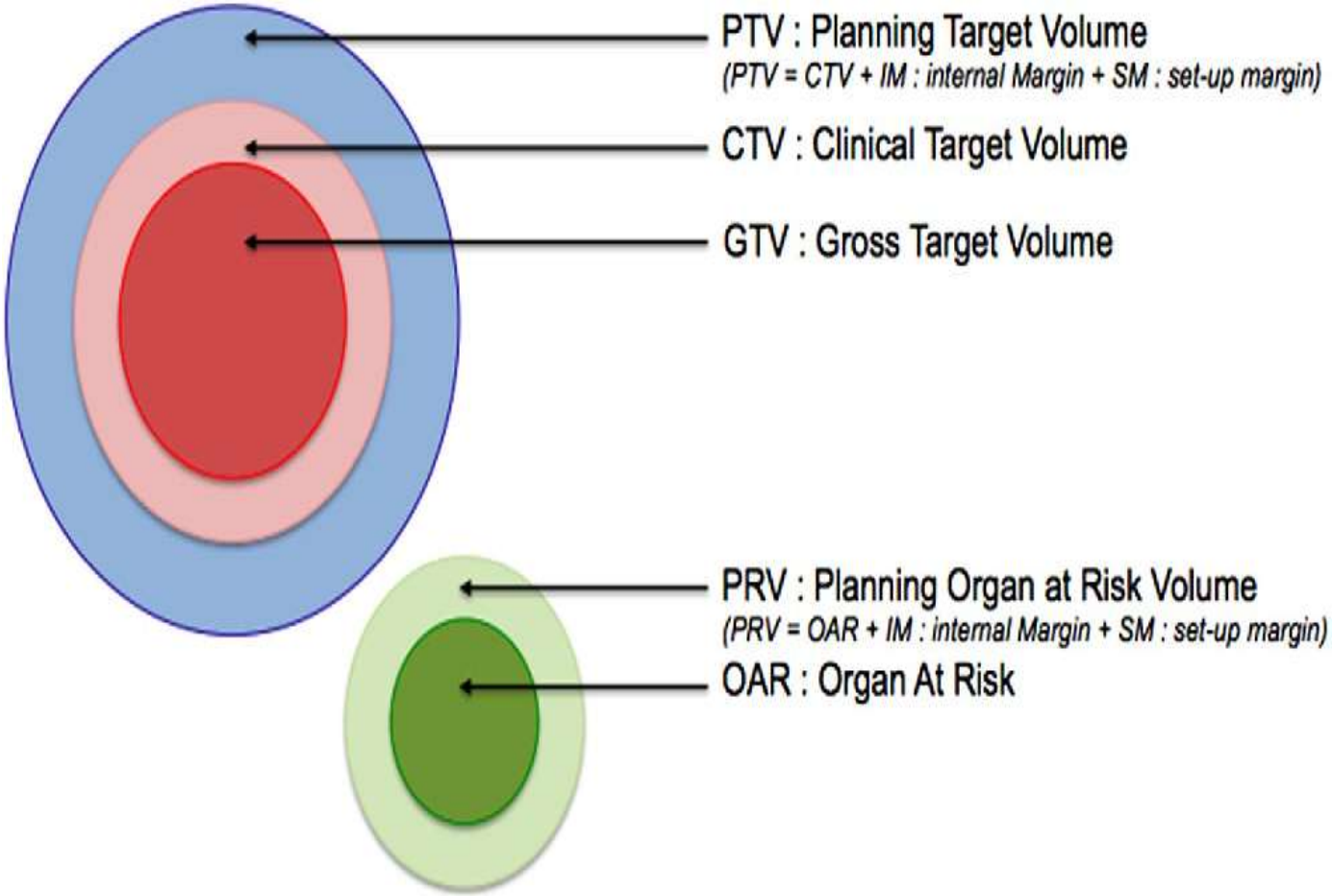

Paradigm shift from conventional to conformal Radiotherapy
Irradiated Volume
Treatment Volume
Target Volume
(a) ICRU 29
Irradiated Volume
Treated Volume
PTV
CTV
GTV
(b) ICRU 50
Irradiated Volume
Treated Volume
PTV
ITV
CTV
GTV
(c) ICRU 62

TRAGET DELINEATION



1. WHAT YOU SEE THAT IS GTV
2. NO CTV
3. DETERMINE ITV IF NO MOTION MANAGEMNET IN EXTRACRANIAL SBRT
4. GIVE 1-2MM PTV TO GTV

OAR

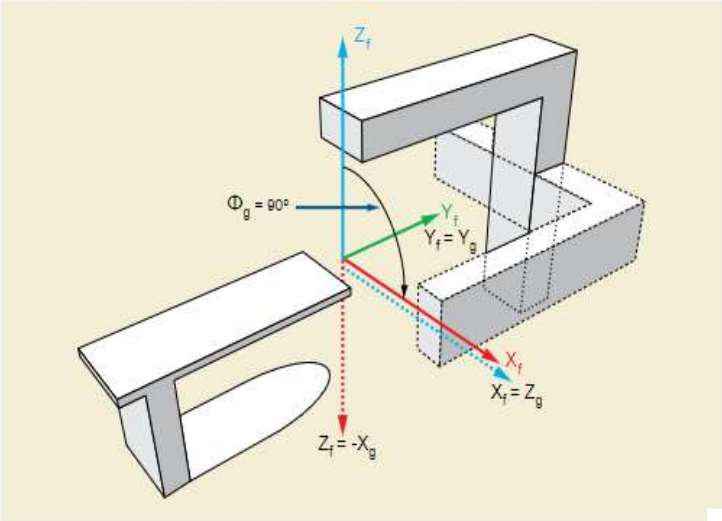

PTV : Planning Target Volume
(PTV = CTV + IM : internal Margin + SM : set-up margin)
CTV : Clinical Target Volume
GTV : Gross Target Volume
PRV : Planning Organ at Risk Volume
(PRV = OAR + IM : internal Margin + SM : set-up margin)
OAR : Organ At Risk

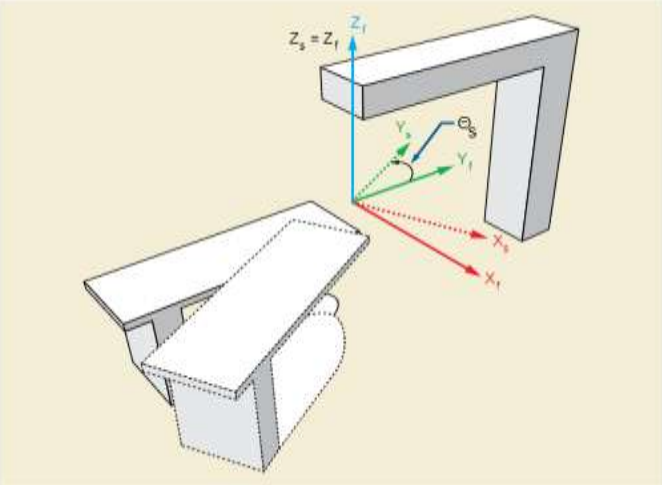
Review your contour

Notes to physics

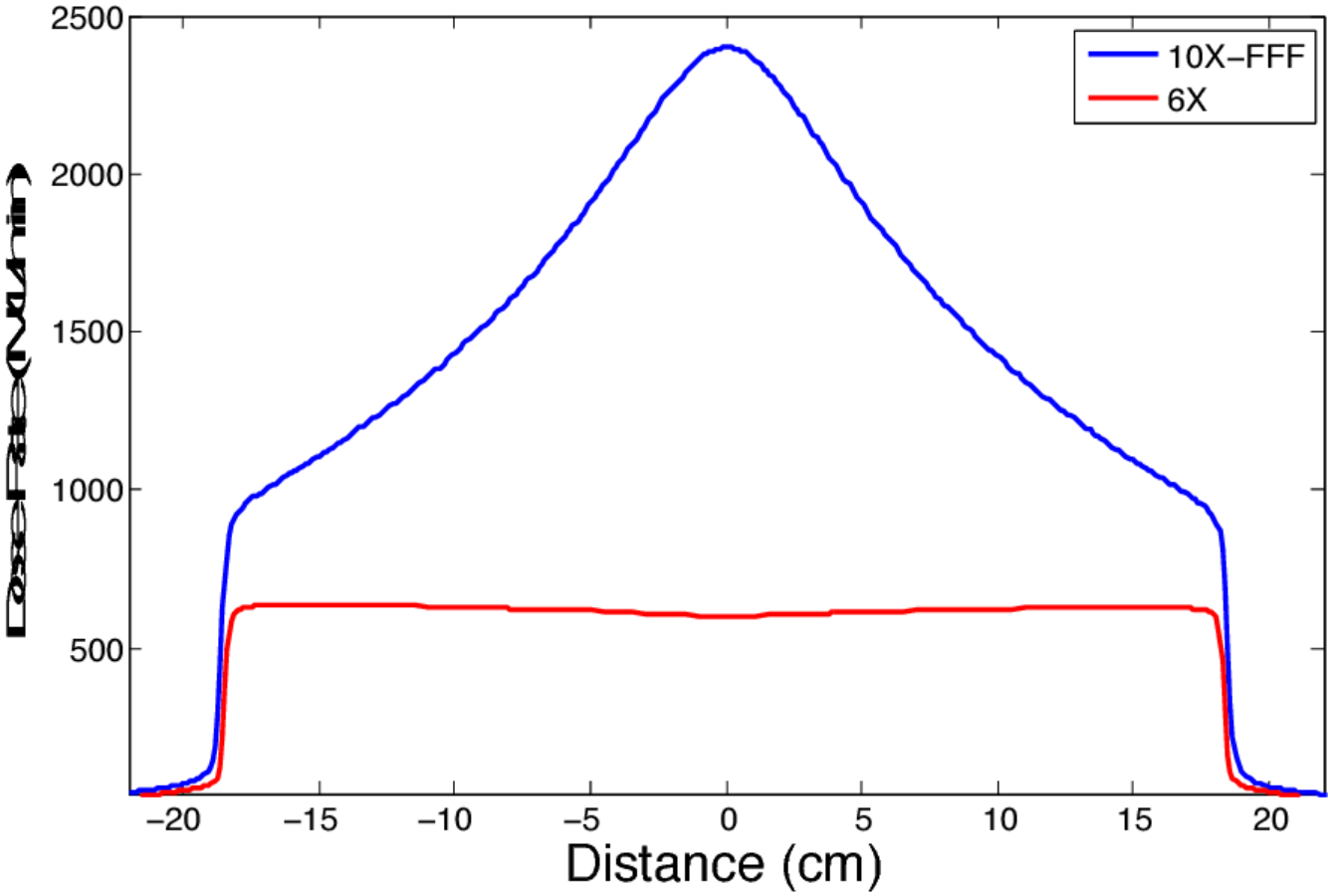
DOSE PRESCRIPTION

Isocentric vs Nonisocentric

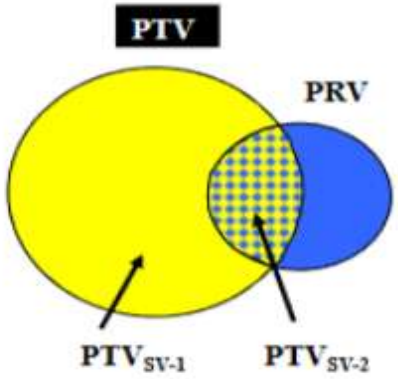




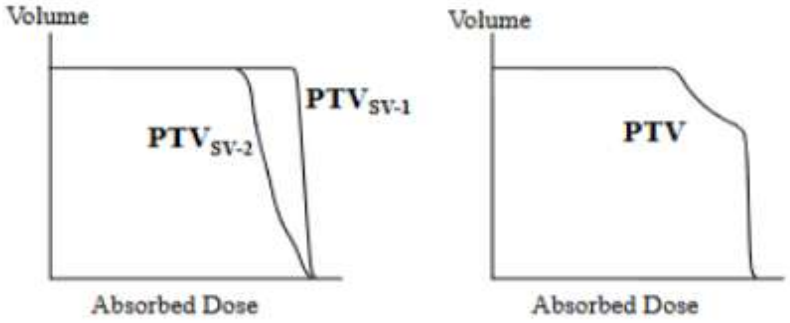
FFF vs no FFF

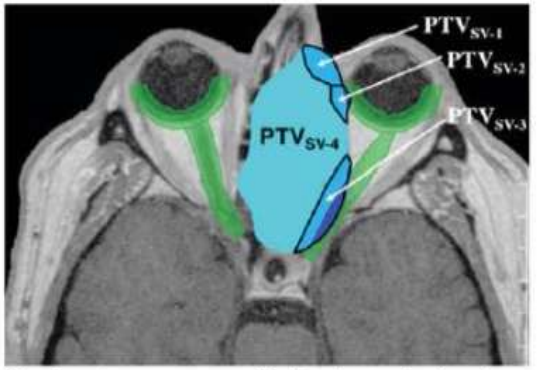

2500
2000
1500
1000
500
10X–FFF
6X
−20
−15
−10
−5
0
5
10
15
20
Distance (cm)

Junction volume



$$PTV = PTV_{SV-1} + PTV_{SV-2}$$





Planning aims

PTV
- median dose (D_{50} %): 70.0 Gy
- near-min dose (D_{98} %): ≥ 66.5 Gy
- near-max dose (D_2 %): ≤ 74.9 Gy

Optic nerves
- near-max dose (D_2 %): ≤ 60.0 Gy

Retina
- near-max dose (D_2 %): ≤ 50.0 Gy

Modification to planning aims

PTV

PTV_{SV-1}
- near-max dose (D_2 %): ≤ 74.9 Gy
- near-min dose (D_{98} %): ≥ 66.5 Gy

PTV_{SV-2}
- near-max dose (D_2 %): ≤ 50.0 Gy
- near-min dose (D_{98} %): ≥ 49.0 Gy

PTV_{SV-3}
- near-max dose (D_2 %): ≤ 60.0 Gy
- near-min dose (D_{98} %): ≥ 58.0 Gy

PTV_{SV-4}
- median dose (D_{50} %): 70.0 Gy
- near-max dose (D_2 %): ≤ 74.9 Gy
- near-min dose (D_{98} %): ≥ 66.5 Gy

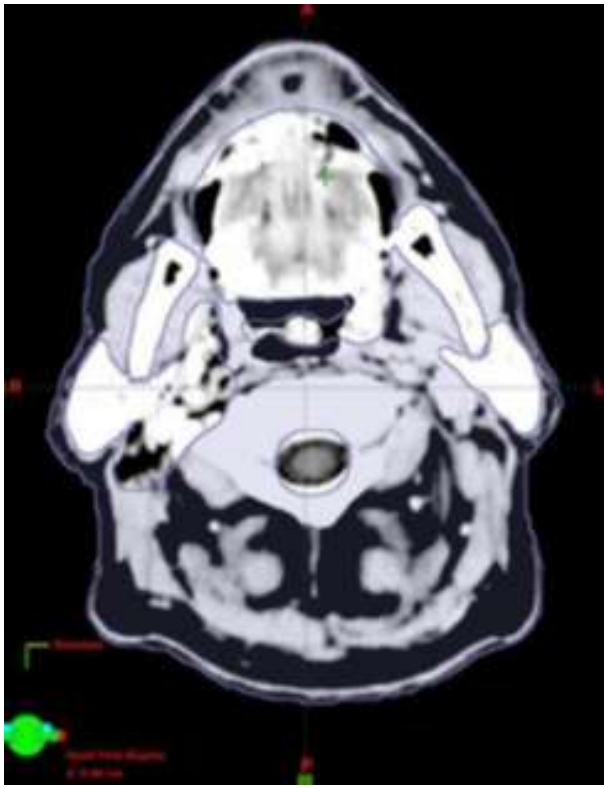
PRV optic nerves
- near-max dose (D_2 %): ≤ 60.0 Gy

PRV retina
- near-max dose (D_2 %): ≤ 50.0 Gy

Accept under dosage in one of the Subvolumes

RVR

1. For plan optimization, additional dose may be dumped in RVR.
2. High absorbed dose in RVR



MORNING - MAINTAINING EQUILIBRIUM

Hot and cold water management at bath room

DAY TIME- MAINTAINING EQUILIBRIUM

EVENING-MAINTAINING EQUILIBRIUM

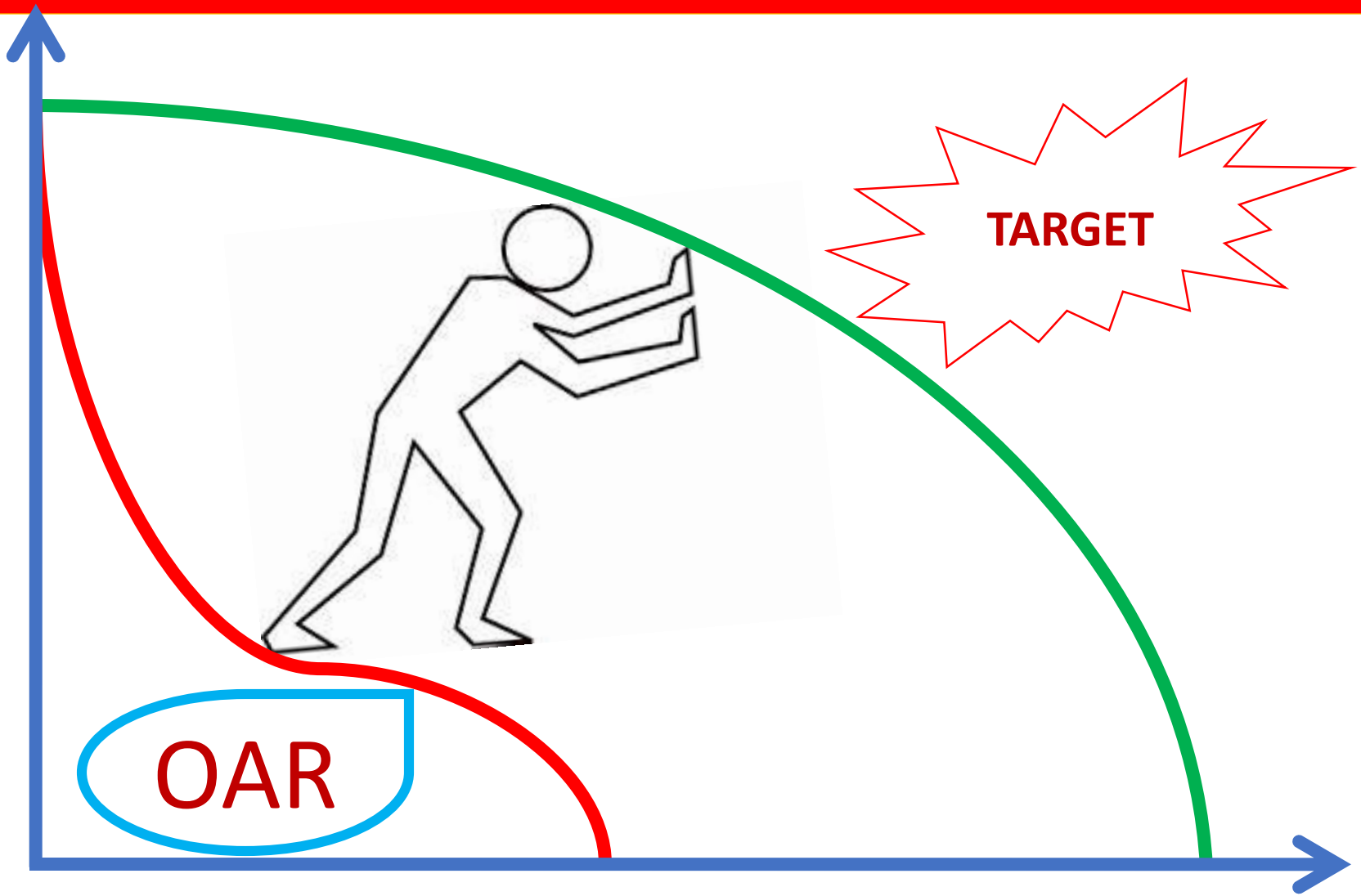
GOAL

Goal

Maximum dose to Tumor

minimum dose to critical normal tissues

PUSHING BACKWARD AND FORWARD AT A TIME DIFFICULT BUT NOT IMPOSSIBLE



Michael Goitein

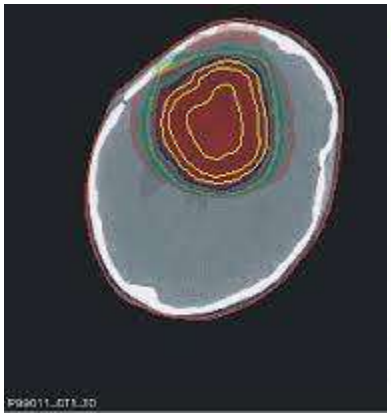
Fig. 1 Michael Goitein in 2007 delivering an invited lecture in the Massachusetts General Hospital Ether Dome. Reprinted from [1] with permission from Elsevier

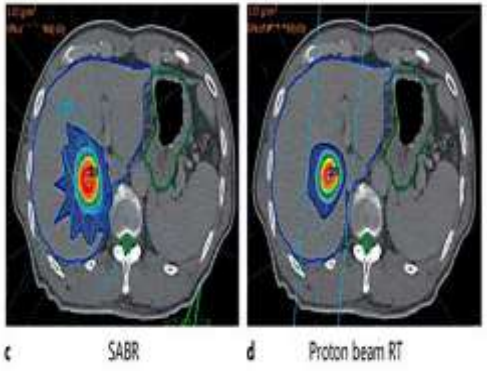
Fig. 2 A team of three senior physicists evaluating a complex treatment plan: Michael Goitein at the center with his colleagues. On the right side of the figure are an operation terminal (lower side) of the VAX computer and a computer-driven image display device (upper side) (probably in the early 1980s). Reprinted from [1] with permission from Elsevier

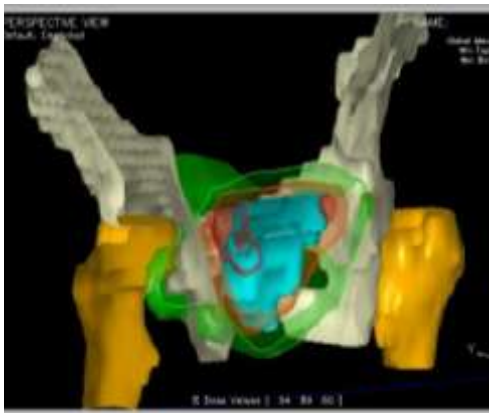
MLC and CONE

Dose displaying

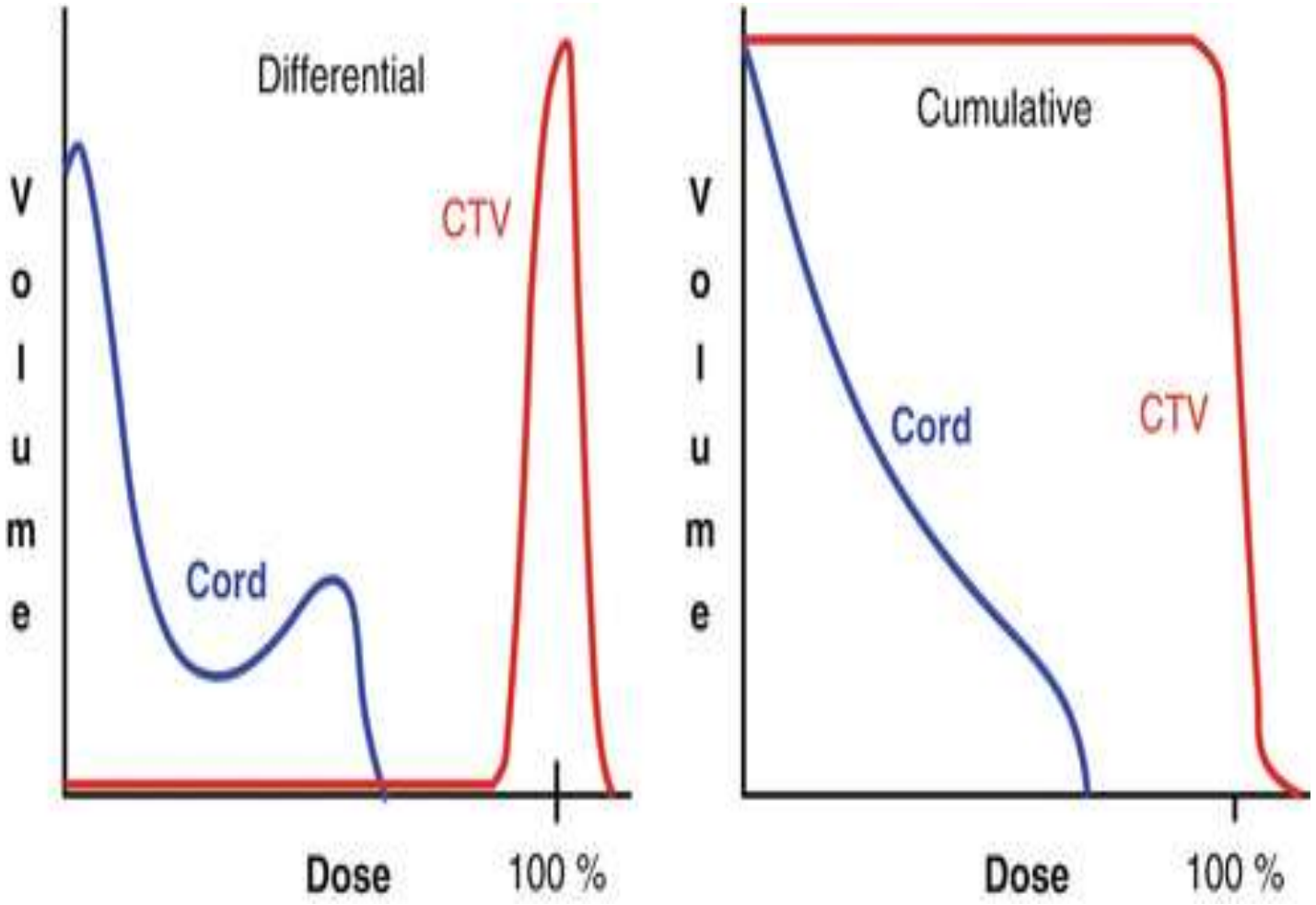
1. Isodose Contours: Set of closed contours linking voxels of equal dose
2. Color Wash: The coding of CT and Dose in the same voxel through the modulation of both intensity (CT) and color (Dose)
3. Isodose Surfaces: The Shaded surface (pseudo 3D) representation of the dose level and selected VOI





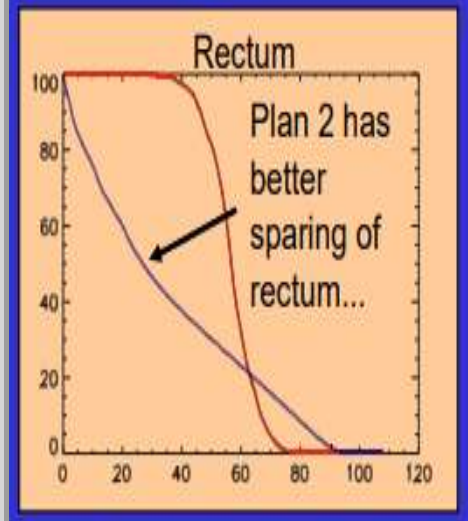


Basics – DVH


Differential
CTV
Cord
Volume
Dose
100 %
Cumulative
CTV
Cord
Volume
Dose
100 %

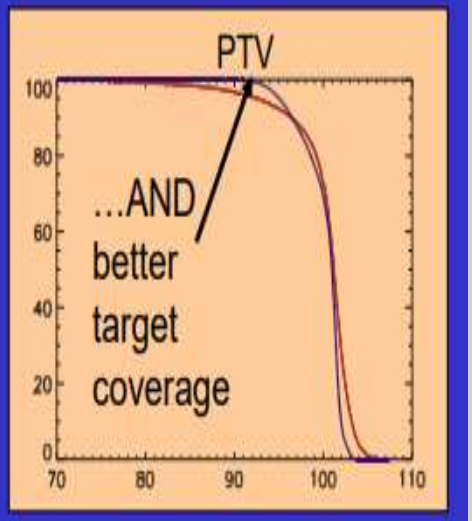
PLAN CONFLICTS

Visual assessments difficult to quantify.

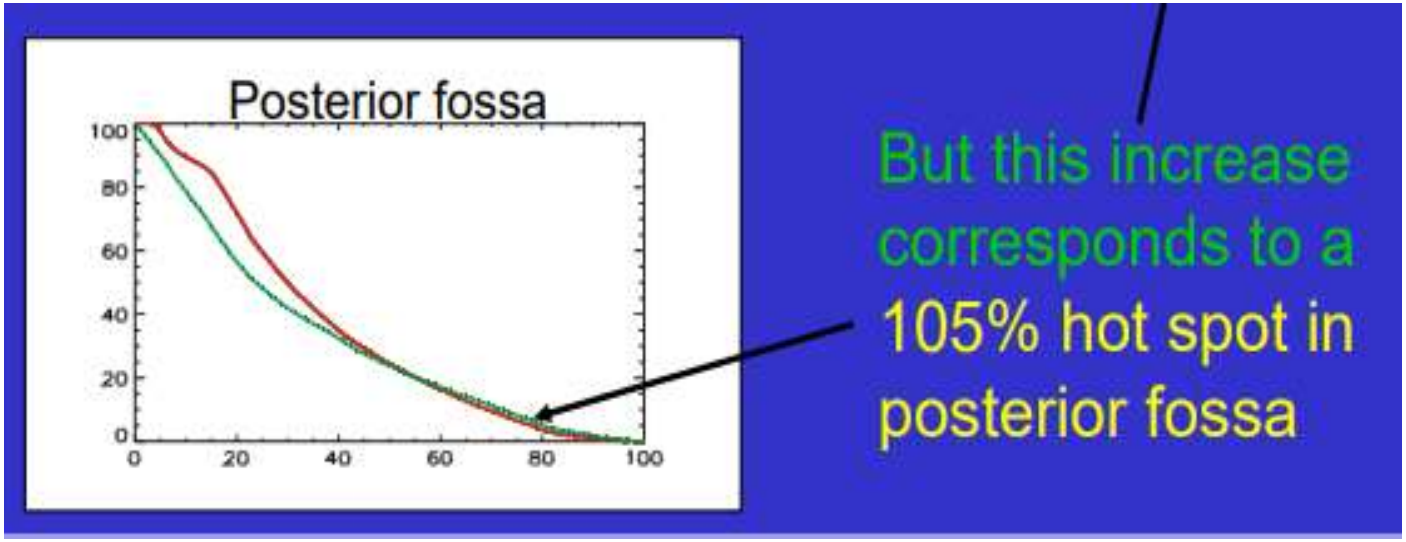


Many, often conflicting indices required to fully characterise a plan

Or..



Misleading DVH



DVH pitfalls

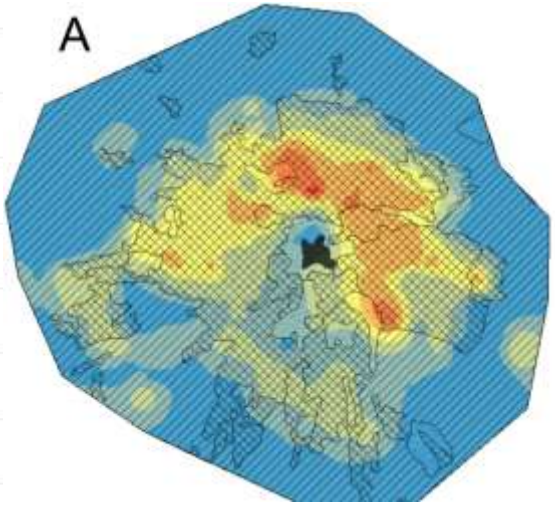
1. Insensitive to hot spot and cold spot
2. Shape of DVH alone can be misleading
3. DVH is the most direct and informative representation of a treatment plan available
4. 3D dose distribution are large and cumbersome to analyze quantitatively
5. User interactivity is essential to extract the most information from dose distribution.
6. Clinical studies have shown that DVH metrics correlate with patient toxicity outcomes.
7. A drawback of the DVH methodology is that it offers no spatial information; i.e., a DVH does not show where within a structure a dose is received.

Spatial Distribution

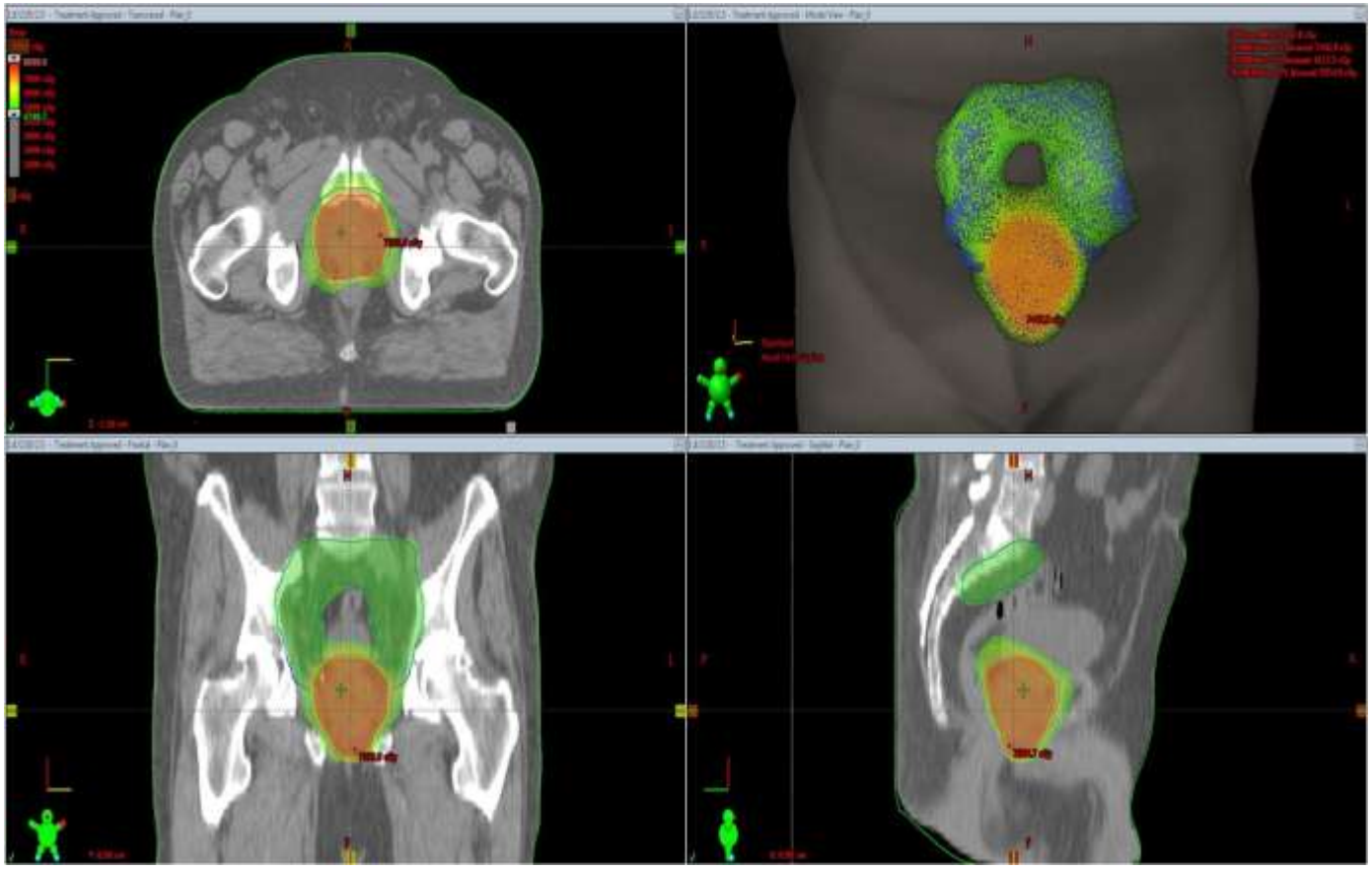
Synonyms for Spatial distribution

13 other terms for spatial distribution - words and phrases with similar meaning

geographical distribution	n.
geographical allocation	n.
geographical representation	n.
geographic representation	n.
geographical spread	n.
area distribution	n.
geographic coverage	n.
geographic range	n.
geographic spread	n.
geographical coverage	n.
territorial distribution	n.
spacial distribution	n.
spatial spread	n.



Plan evaluation



MLC and CONE

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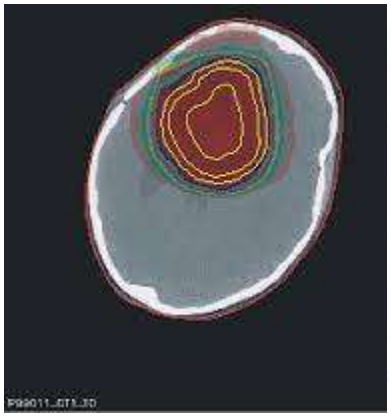
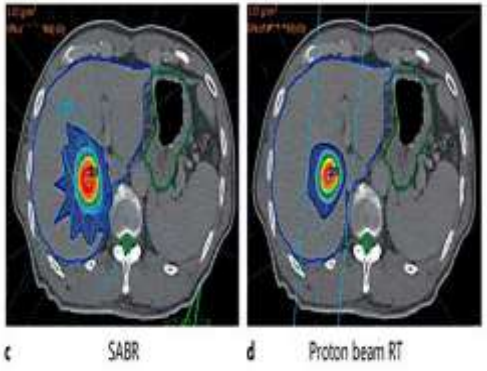
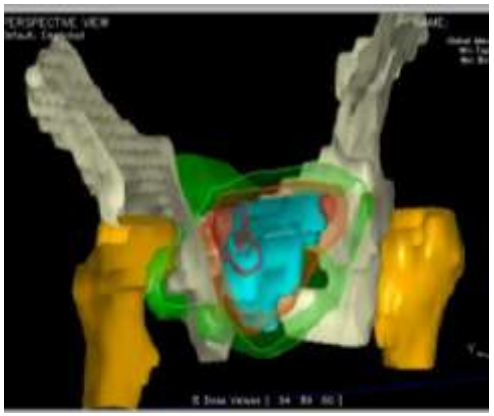






CBCHOP

CB-CHOP: A simple acronym for evaluating a radiation treatment plan

Mary Dean, MD; Rachel Jimenez, MD; Eric Mellon, MD, PhD; Emma Fields, MD; Raphael Yechieli, MD; Raymond Mak, MD

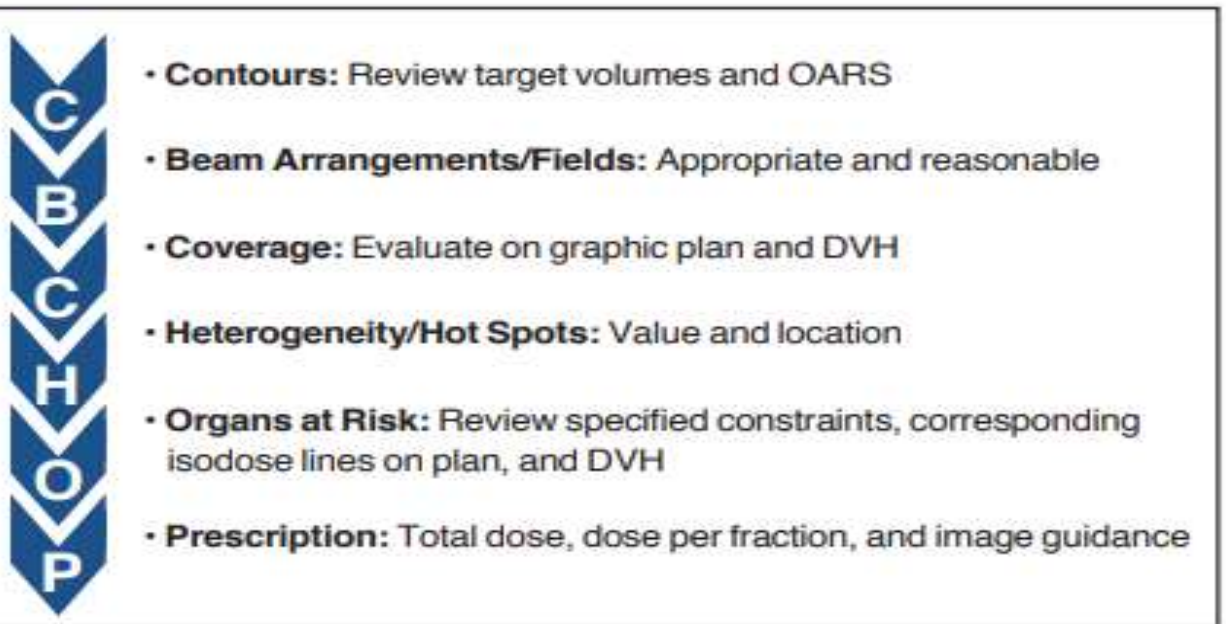


FIGURE 1. *Flowchart diagram summarizing the CB-CHOP acronym and components of plan quality.*

Mary Dean/Applied Radiation Oncology/2017

COSID INDEX

Original Article

Dr. Kanhu's COSID Index: An Acronym for Plan Evaluation in SRS & SBRT

Kanhu Charan Patro, Ajitesh Avinash[1], Arya Pradhan[1], Chittaranjan Kundu, Partha Sarathi Bhattacharyya, Venkata Krishna Reddy Pilaka, Mrityunjaya Muvvala, Arunachalam Chithambara[2], Ayyalasomayajula Anil Kumar[2], Srinu Aketi[2],Parasa Prasad[2], Venkata Naga Priyasha Damodara, Veera Surya Premchand Kumar Avidi, Mohanapriya Atchaiyalingam, Keerthiga Karthikeyan

Department of Radiation Oncology, Mahatma Gandhi Cancer Hospital and research Institute, Visakhapatnam, Andhra Pradesh, [1]Department of Radiation Oncology, Acharya Harihar Post Graduate Institute of Cancer, Cuttack, [2]Department of Medical Physics, Mahatma Gandhi Cancer Hospital and research Institute, Visakhapatnam, Andhra Pradesh, India

COSID INDEX STEPS

Table 1: Showing the five major parameters of SRS/SBRT plan evaluation (COSID INDEX)

COSID INDEX	
	Index Name
C	**Coverage Index**
	Median absorbed dose of PTV, D50%
	Near-maximum dose, Dnear-max
	Near-minimum dose, Dnear-min
O	**Organ at risk Index**
S	**Spillage Index**
	Conformity Index
	Homogeneity Index
	Gradient Index
I	**Imaging Index**
	Slice by slice evaluation
D	**Delivery Index**
	Complexity of Plan
	Monior Units (MU) Evaluation
	Dose Calculation Parameters
	Pre-verification of Treatment

COSID INDEX

C

COVERAGE INDEX

O

OAR INDEX

S

SPILLAGE INDEX

I

IMAGING INDEX

D

DELIVERY INDEX

Patro K C/Journal of Current Oncology/2022

Coverage Index

PTV/CTV/GTV

D_2/D_{98}

95-107

Dmax

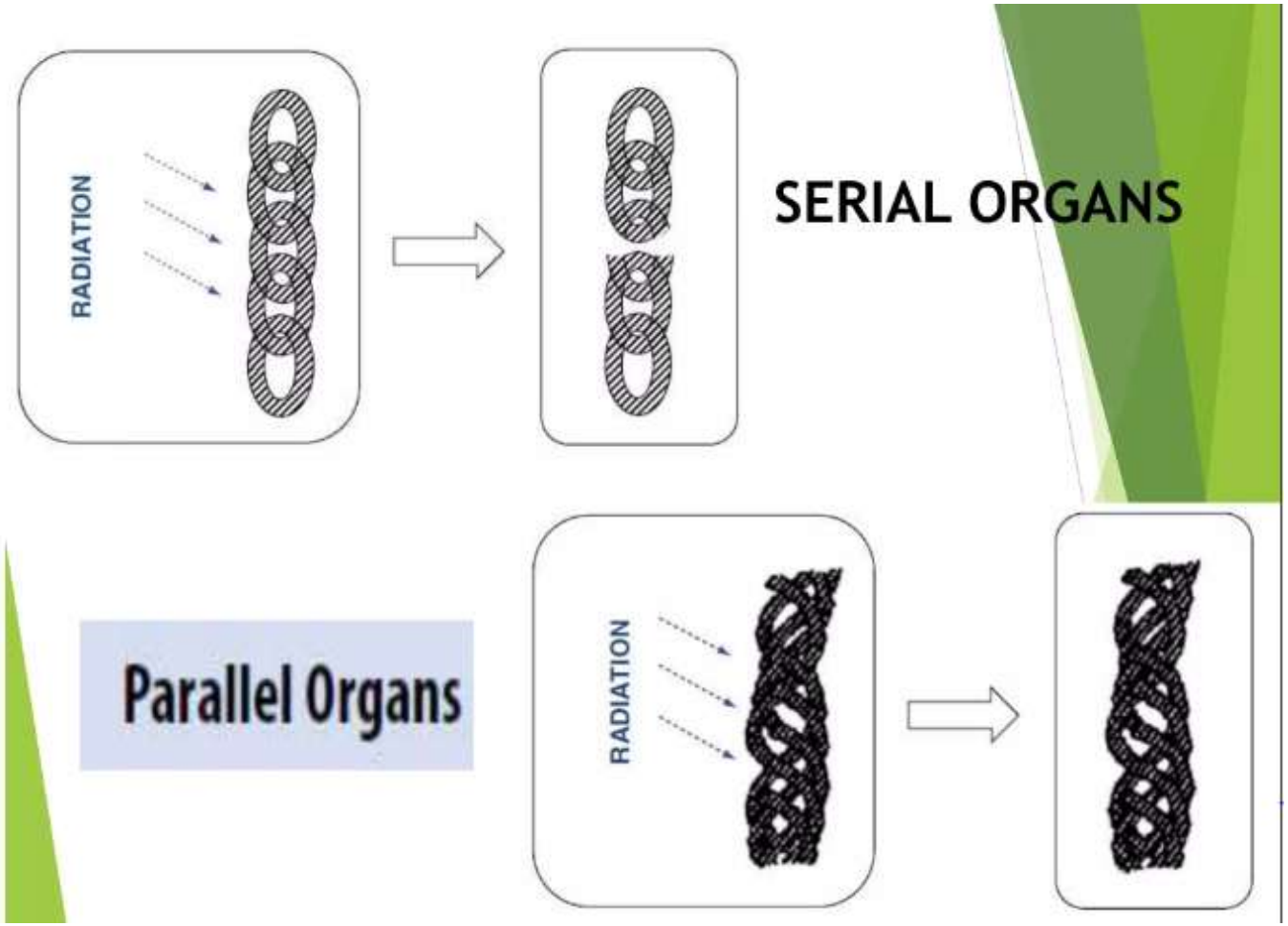
OAR INDEX

Max dose in series organ

Mean dose in parallel organ

Volumetric analysis

Basics of plan evaluation – Serial vs Parallel



Basics of plan evaluation – Spillage Index

Conformity index

Homogeneity index

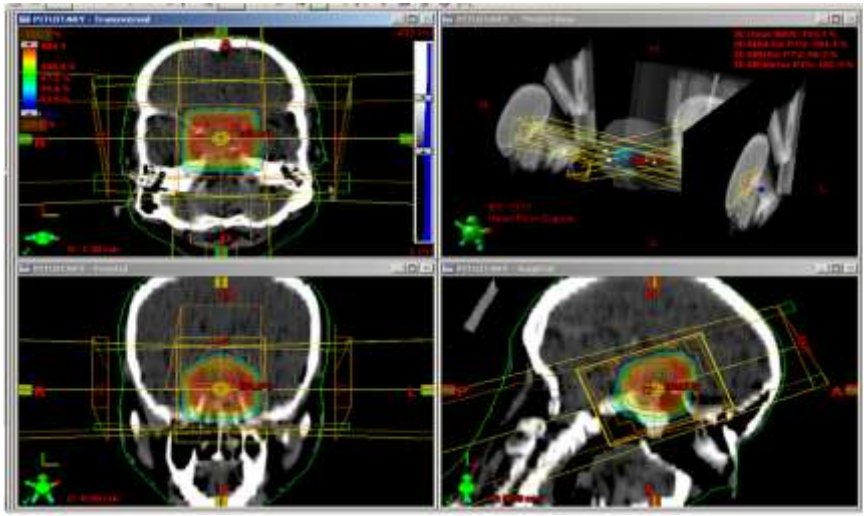
Gradient index

Basics of plan evaluation – Imaging Index

Axial view

Coronal view

Sagittal View



Patro K C/Journal of Current Oncology/2022

Basics of plan evaluation – Delivery index

Complexity of plan

Complexity of Delivery

MU

Example

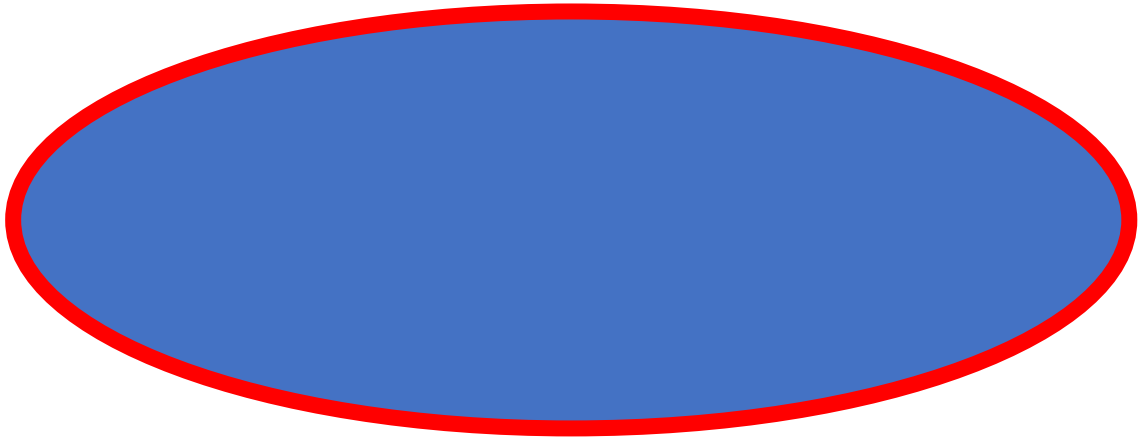
PTV coverage index

SL NO	PARAMETER	VALUE
1	D_{MAX}	36.43Gy
2	$D_{95\%}$	31.01Gy
3	$D_{100\%}$	28.23Gy
4	$V_{95\%}$	99.99%
5	**$V_{30\ Gy}[V_{100\%}]$**	**99.56%**
6	$V_{110\%}$	44.45%
7	$V_{120\%}$	0.03%
8	$V_{130\%}$	0%

1. Prescription Isodose level is usually not 100% PD covering 100% PTV
2. Often 95% PD covering 95% PTV or higher
3. Or 100% PD covering 95% PTV or higher.

Michael Torrens,/J Neurosurg (Suppl 2)/2014

Conformity



- CI = 1 ideal conformation.
- CI >1 irradiated volume > target volume
- CI < 1 target volume is only partially irradiated

- CI values have been defined to determine the quality of conformation (RTOG).
- 1 < CI < 2 comply with the treatment plan
- 2 < CI < 2.5 or 0.9 < CI < 1minor violation
- 2.5 CI < 0.9 major violation.

RTOG conformity index

- Is your desired defined dose is confined to PTV ?
- FORMULA
  - VOLUME OF PRESCRIPTION ISODOSE/PTV VOLUME
- 43.798/37.491=1.17
- DESIRABLE=1

[Sonja Petkovska
Proceedings of the Second Conference on Medical Physics and Biomedical Engineering]

The conformity index was first proposed in 1993 by the Radiation Therapy Oncology Group (RTOG) and described in Report 62 of the International Commission on Radiation Units and Measurements (ICRU). It is presented as a relation between the volume of the reference dose (V_{RI}) and the target volume(TV).

$$Conformity\ index_{RTOG} = V_{RI}/TV \quad (1)$$

According to the RTOG guidelines, ranges of conformity index values have been defined to determine the quality of conformation. If the conformity index is situated between 1 and 2, the treatment is considered to comply with the treatment

Paddick conformity index

- FORMULA

$$\frac{(\text{VOLUME OF PRESCRIPTION ISODOSE IN AREA OF INTEREST})^2}{\text{PTV VOLUME X VOLUME OF PRESCRIPTION ISODOSE}}$$

- =39.764 x 39.764 /37.494 x43.798 =0.96
- IDEAL= > 0.85. AND <1

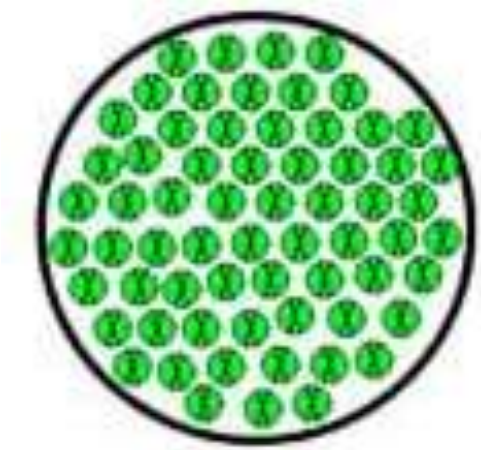
This inadequacy has led to the development of the Paddick Conformity Index (PCI).[48] This value is the coverage multiplied by the Selectivity Index:

$TV_{PIV}^2/(TV \times PIV)$.

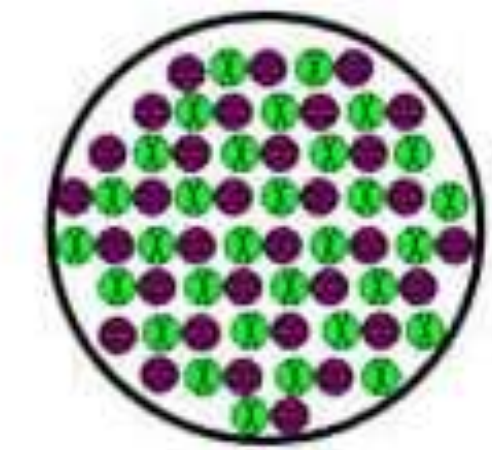
A perfect plan has a score of 1, whereas less perfect plans have a score of < 1. An ideal value for PCI conformity could be > 0.85.

Michael Torrens,/J Neurosurg (Suppl 2)/2014

Homogenous vs heterogenous



NON STEROTAXY
HOMOGENOUS PLAN



STEROTAXY
HETEROGENOUS PLAN

FOR EXAMPLE MARGINAL DOSE IS 20 Gy AT 80% MEANS YOU CAN ACCEPT HOT SPOT INSIDE 125% i.e. 25Gy

80% = 18Gy

100%= 18/80 X 100 = 25Gy

HOMOGENITY index

- How homogeneous your dose inside the PTV?
- FORMULA
    - MAXIMUM DOSE/PRESCRIPTION DOSE
- 36.43Gy/30Gy=1.21
- DESIRABLE = 1.1-1.3

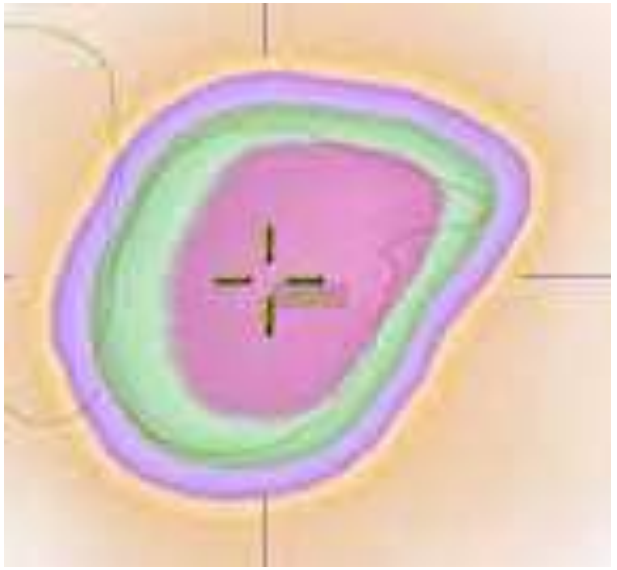
It is an objective tool to analyse the uniformity of dose distribution in the target volume

Homeogeneity Index (HI) = $D_{2\%} - D_{98\%}/D_{50\%}$

Ideal HI: 1.1 – 1.3

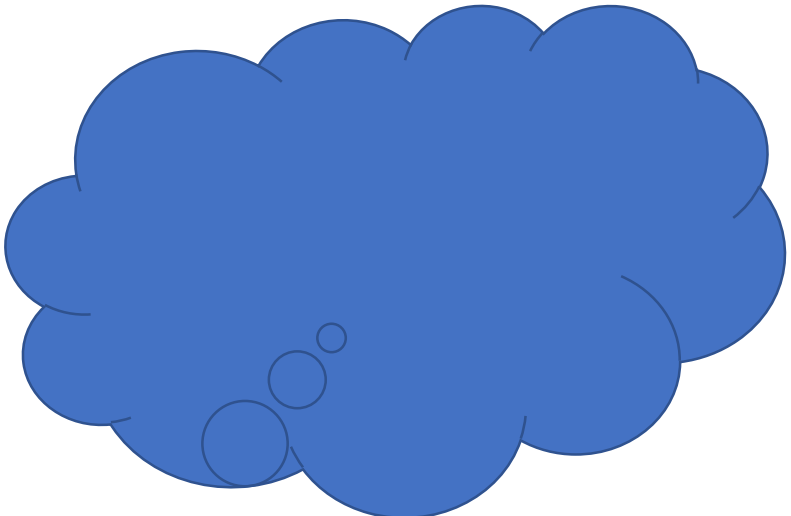
Dose fall off- Gradient index

- Dose fall off observation is very much needed in this evaluation under headings
- Gradient index
- Difference between various isodose lines
- e.g between 80% and 60%- ideal- <2mm
- Between 80% and 40%- ideal- < 8mm
- For that reason, we must calculate equivalent radius



Equivalent radius

- To evaluate dose gradient, we must find out difference between radius of various isodose line
- But none is iso spherical
- We must find out equivalent radius from formula
- First find out the specified isodose volume
- Then calculate the radius
- $V=4/3\ \pi r^3$
- $r= (3V/4\pi)^{1/3}$



Equivalent radius

SL NO	PARAMETER	VOLUME	RADIUS
1	**100% ISODOSE**	43.79CC	2.19mm
2	**80% ISODOSE**	64.45CC	2.49mm
3	**60% ISODOSE**	101.19CC	2.89mm
4	**50% ISODOSE**	130.84CC	3.15mm
5	**40% ISODOSE**	177.96CC	3.49mm

$$r = (3V/4\pi)^{1/3}$$

Gradient index

- FORMULA
  - Difference of equivalent radius of prescription isodose and equivalent radius of 50% isodose
- 2.19mm-3.15mm=0.96mm
- It should be between 0.3 to 0.9

Distance between various isodose lines

- BETWEEN 80% AND 60%- IDEAL-<2mm
  - HERE- 0. 4mm
- BETWEEN 80% AND 40%- IDEAL- <8mm
  - HERE- 1mm

EORTC-22952-26001

ISODOSE LINES

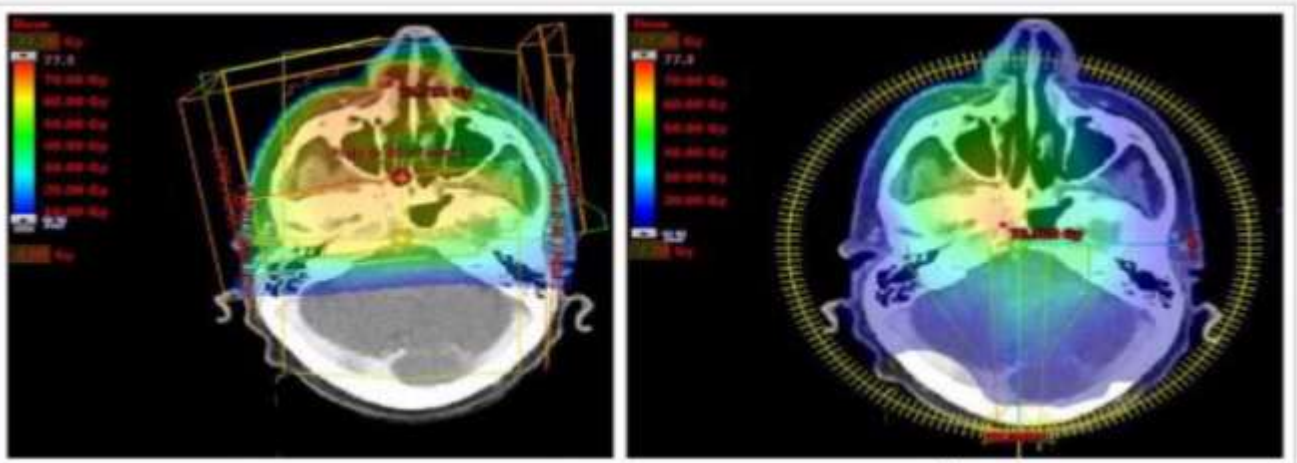
COLOUR	ISODOSE LINE
Dark green	100%
Light green	80%
Sky green	60%
Pink	50%
Blue	40%

OAR coverage

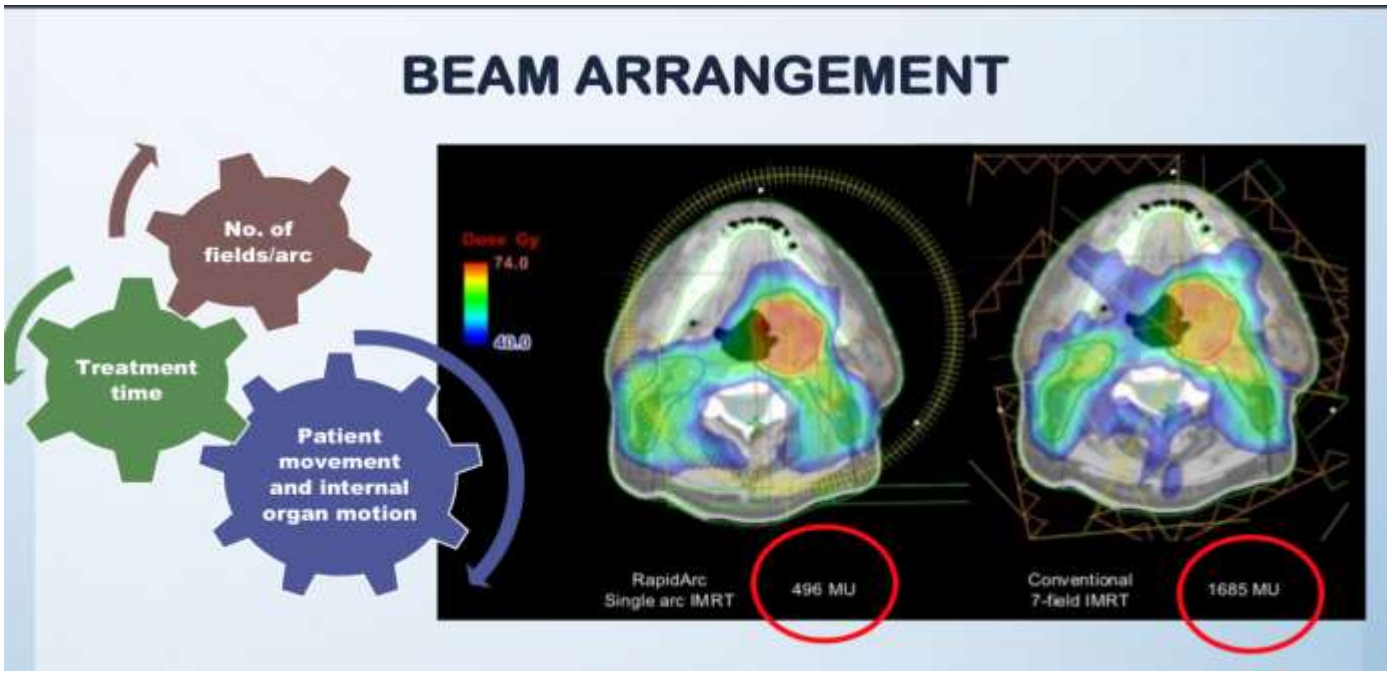
SL NO	ORGAN	DESIRABLE	ACHIEVED
1	**RT. EYE**	MAX <22.5Gy	1.97Gy
2	**LT. EYE**	MAX <22.5Gy	4.4Gy
3	**RT. OPTIC NERVE**	MAX <22.5Gy	2.3Gy
4	**LT. OPTIC NERVE**	MAX <22.5Gy	5.5Gy
5	**OPTIC CHIASM**	MAX <22.5Gy	7.5Gy
8	**BRAIN STEM**	MAX 23-31Gy	10.01Gy
9	**RT. COCHLEA**	MEAN <25Gy	<1Gy
10	**LT. COCHLEA**	MEAN <25Gy	<1Gy

Low dose bath

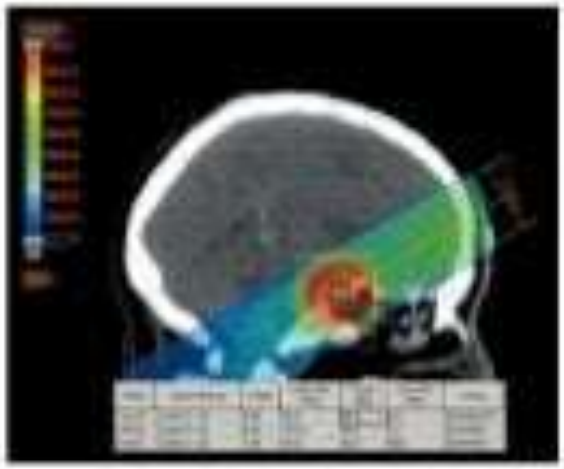
Figure 1. A comparison between a three-dimensional conformal radiotherapy (3DCRT) plan and a volumetric modulated arc therapy (VMAT) plan for a head and neck tumour. Notice the larger volume of the posterior fossa receiving a low dose bath in the VMAT plan. (**a**) 3DCRT; (**b**) VMAT.

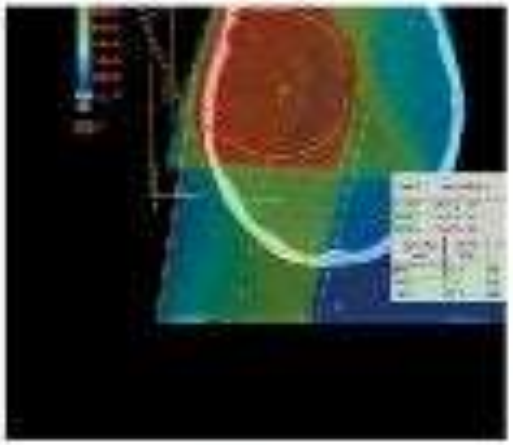


Beam arrangements

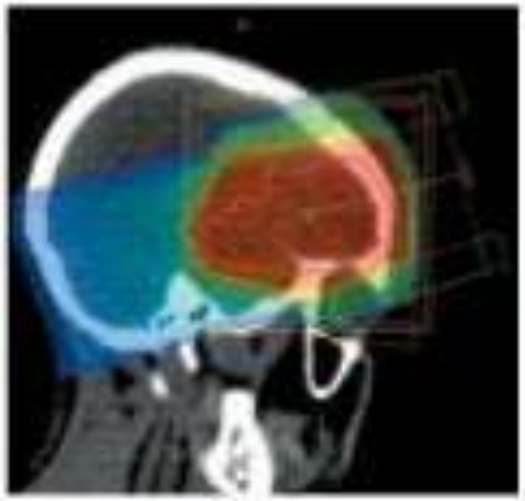


BEAM entry exit point

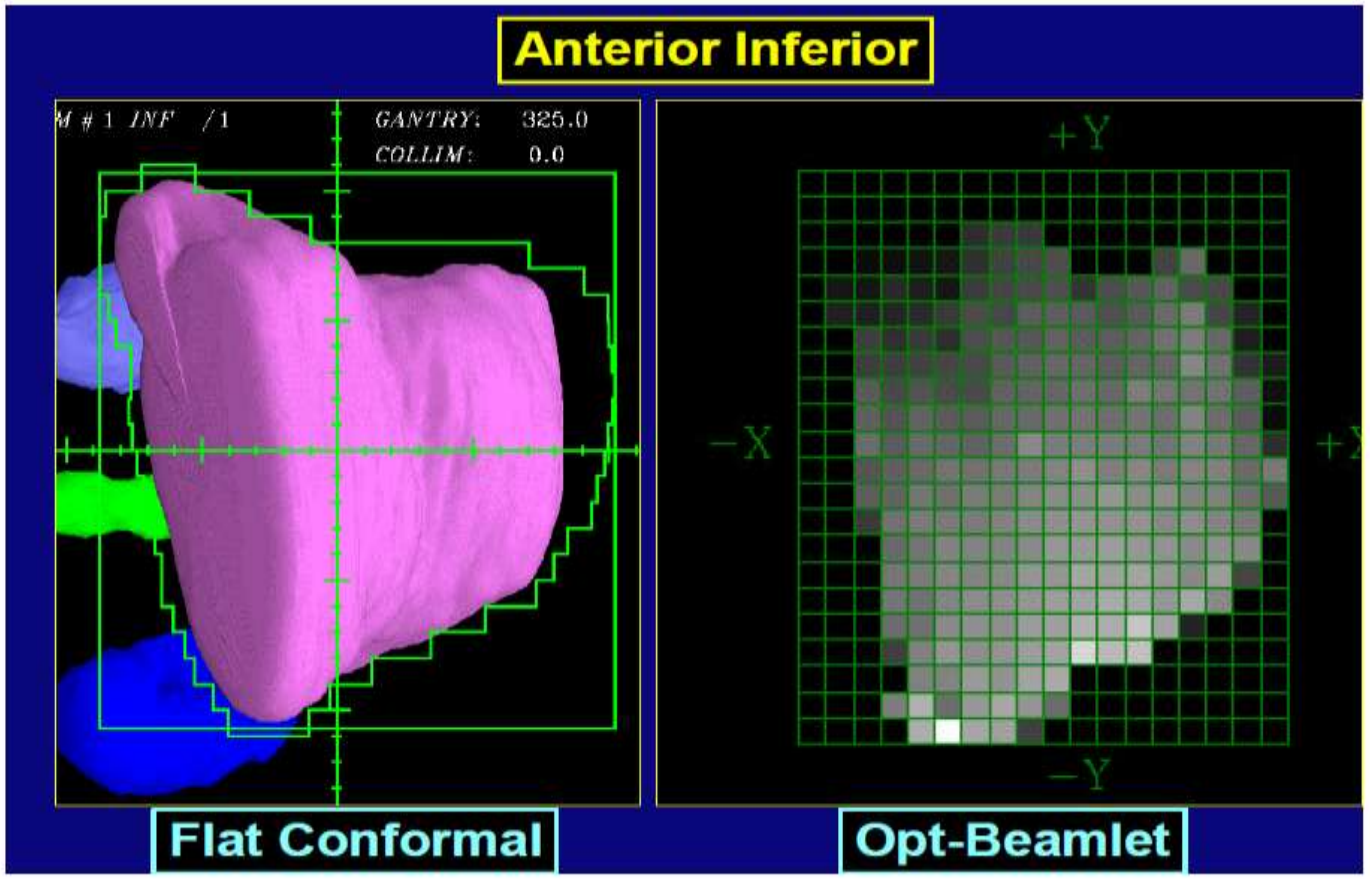




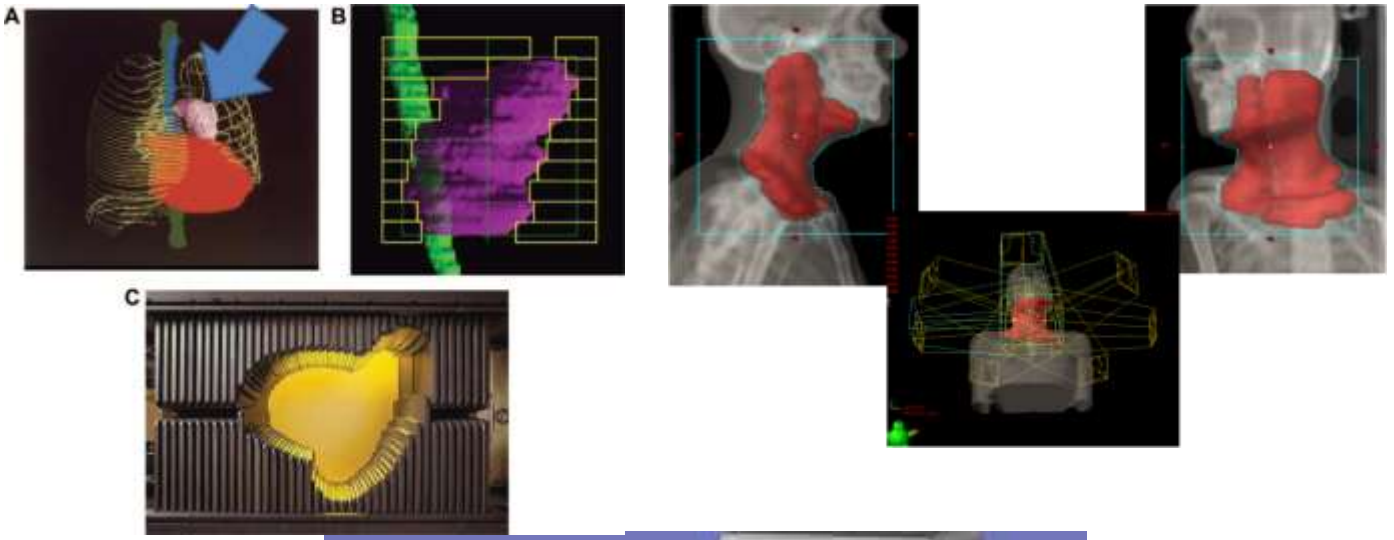
Patient positioning: A neutral head position with the patient supine is easily reproducible. Noncoplanar beams can be used to avoid entry and exit dose to organs at risk (OAR).

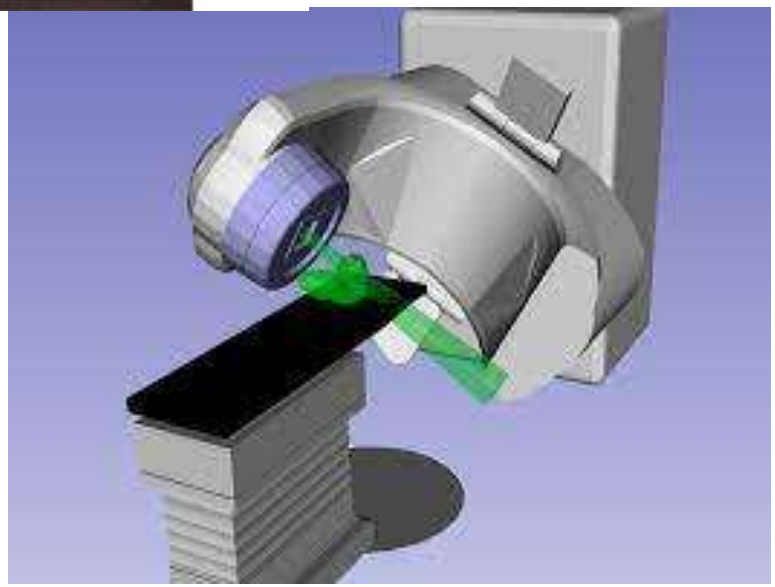


3D vs beamlet

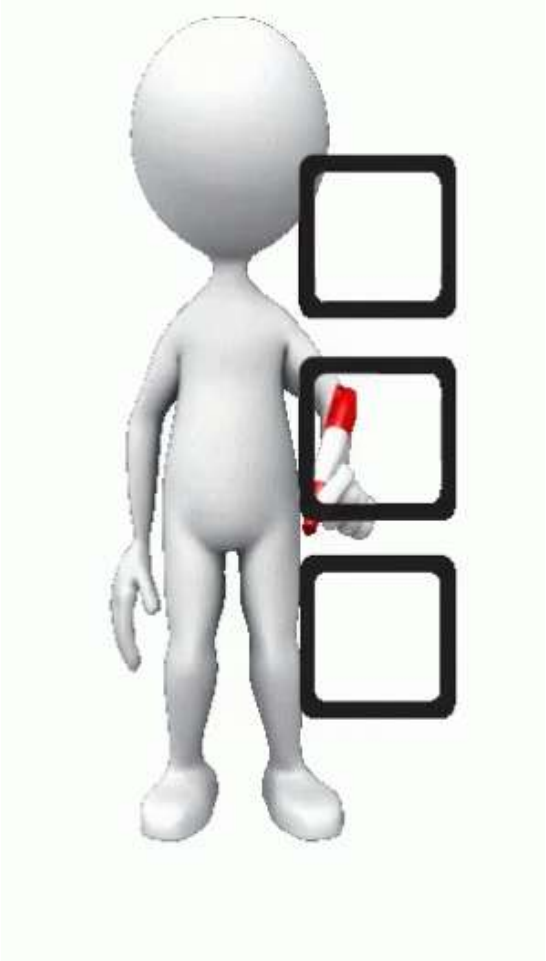


BEV vs REV





Basics of plan evaluation – Check list



Basics of plan evaluation – Check list

TARGET COVERAGE					
	D2	D98	AXIAL	SAGGITAL	CORONAL
GTVp					
GTVn					
CTV					
PTV					

OAR					
	LIMIT	PHASE 1	PHASE 2	TOTAL	VARIATION
OC-[0.03cc]					
RON [0.03cc]					
LON [0.03cc]					
EYE_R MEAN					
EYE_L MEAN					
PAROTID_R MEAN					
PAROTID_L MEAN					
SPINAL CORD [0.03cc]					
BRAIN STEM [0.03cc]					

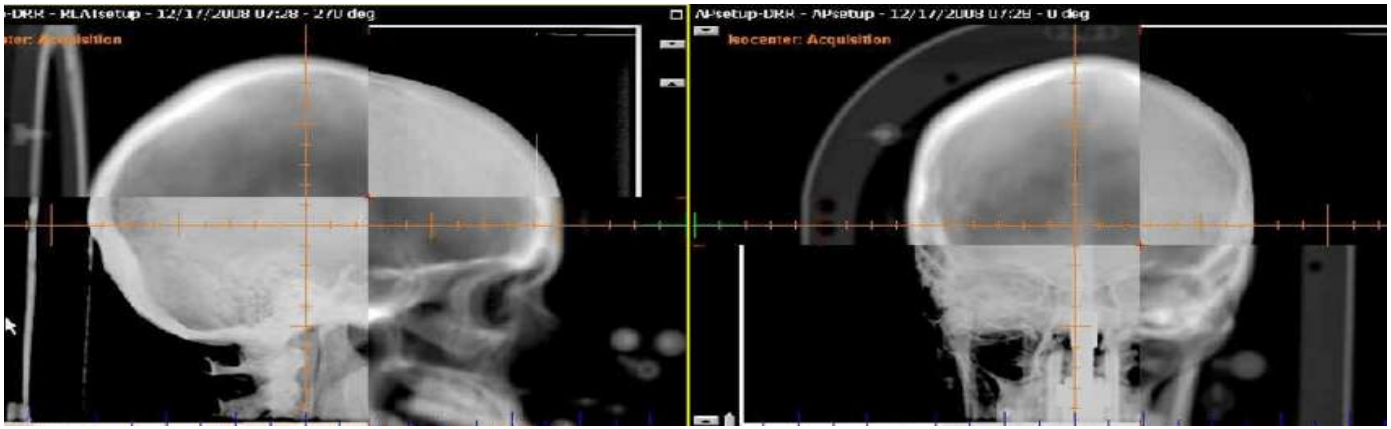
Excel shhet

Patient 4		
Patient name	N VIJAYA LAKSHMI	**TOLERANCES**
UMR	UMR56950	
Sex and Age	50 YEARS & FEMALE	
Technique	VMAT	
Dose per fraction (Gy)	8.5	
No. of fractions	3	
Total dose (Gy)	25.5	
Volume of PTV (cc)	25.143	
Volume of prescription (100%) Isodose (cc)	122.3	
Target volume covered by prescription isodose (cc) INTERSECTION VOLUME	24.665	
Volume of 80% isodose (cc)	37.54	
Volume of 60% isodose (cc)	54.33	
Volume of 50% isodose (cc)	482	
Volume of 40% isodose (cc)	90.22	
Eqv.radius of 100% isodose (cm)	3.08	
Eqv.radius of 80% isodose (cm)	2.08	
Eqv.radius of 60% isodose (cm)	2.35	
Eqv.radius of 50% isodose (cm)	4.86	
Eqv.radius of 40% isodose (cm)	2.78	.
Volume received by 100% isodose (%)	**97.99**	
Maximum dose (Gy)	**32.14**	
Conformity index as per RTOG[VOLUME OF PRESCRIPTION ISODOSE/VOLUME OF PTV]	**4.86**	IDEALLY 1
Conformity index as per Paddic	**0.20**	
Homogeneity index [MAX DOSE/PRESCRIPTION DOSE]	**1.26**	BETWEEN 1-1 TO 1.3
Gradient index [EQUIVALENT RADIUS OF50%-EQUIVALENT RADIUS OF 100%]	**1.78**	BETWEEN 0.3 TO 0.9
Distance b/w 80% iso and 60% iso (cm)	**0.27**	LESS THAN 2MM
Distance b/w 80% iso and 40% iso (cm)	**0.71**	LESS THAN 8MM
OAR DOSES		
BRAIM-PTV [V27Gy]		
OPTIC CHIASMA		
RT OPTIC NERVE		
LT OPTIC NERVE		
BRAIN STEM		
Patient specific QA		<10% deviation

QA IS MANDATORY

For setup Is localizer box is mandatory?

2D verification vs 3D verification



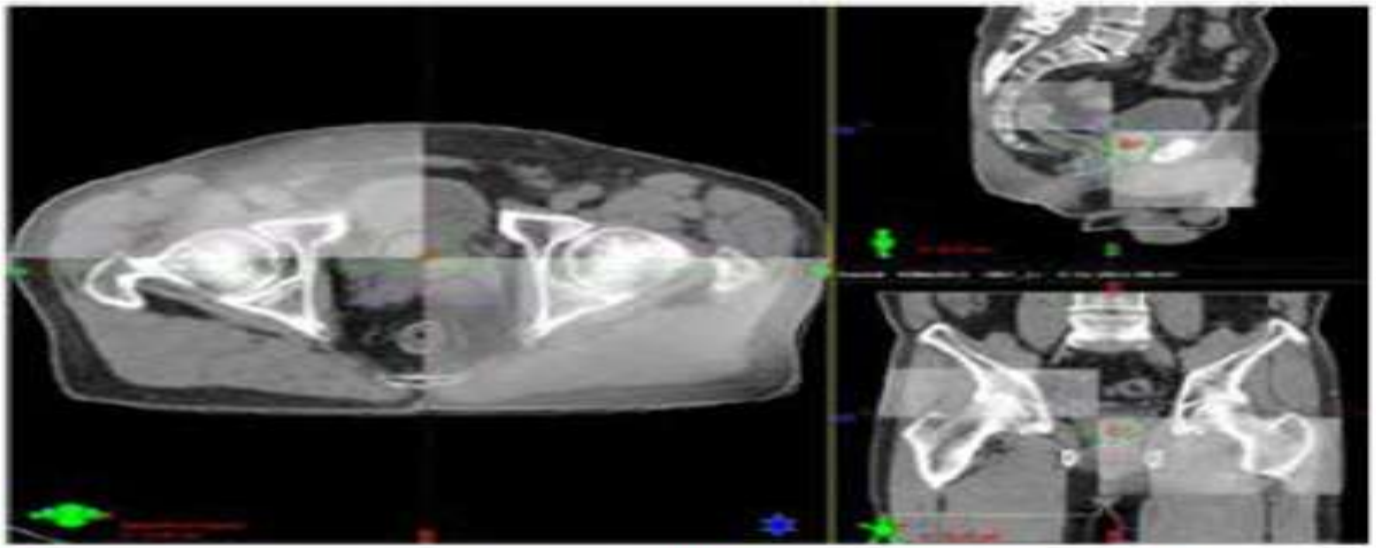
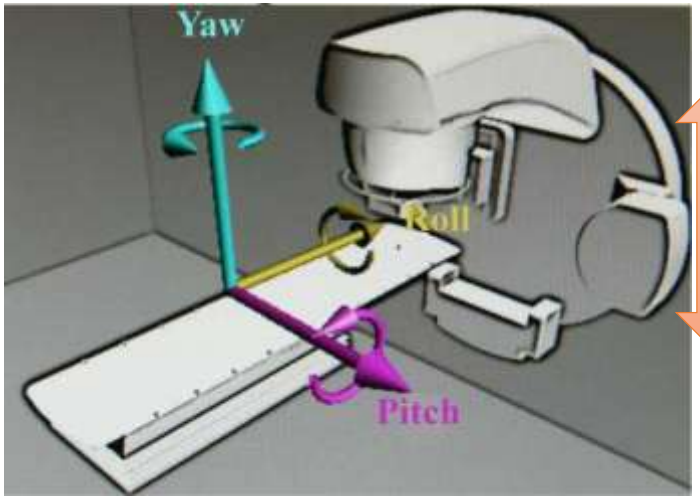
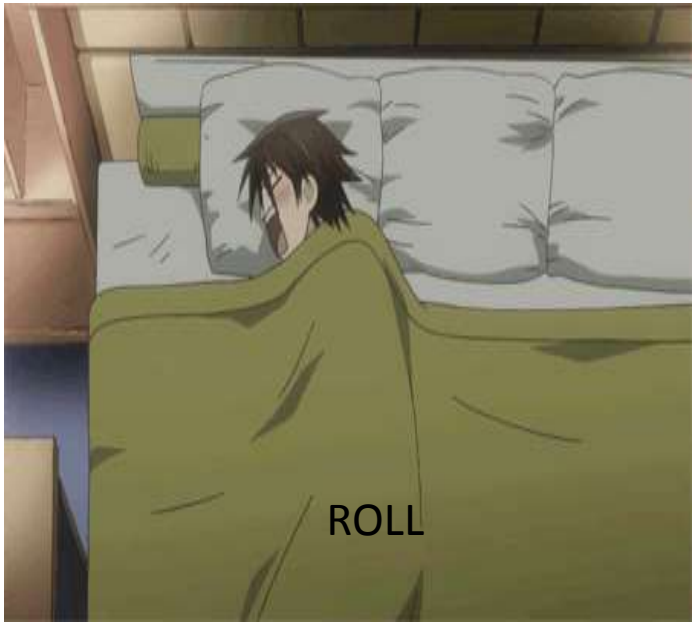


Figure 6: On-board imaging used for IGRT- On-board Cone Beam CT images are registered onto planning CT scan to calculate shifts which are then applied onto the patient's couch to achieve perfect targeting

Hexapod couch



PITCH



ROLL

YAW

TRAIN YOUR BRAIN TO DECREASE THE DOSES TO OARS STRACTURES BUT NOT AT THE COST OF PTV

Take care of OAR otherwise rare will not be rare

RESTRAIN YOURSELF FROM GIVING STRICT CONSTRAIN OTHERWISE TUMOR WILL SUSTAIN.

Stereotaxy class

STEREOTAXY ONE DAY CLASS FOR STUDENTS (8 Hours)

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III. MOTION MANAGEMENT
IV. PLAN EVALUATION
V. QA
VI. NEUROSTEREOTAXY
[METS, SCHWANNOMMA, AVM, PITUITARY, GLOMUS, CAVERNOMA, MENINGOMA, ReRT]
VII. SABR LUNG
VIII. SBRT LIVER
IX. SBRT PANCREAS
X. SBRT PROSTATE
XI. SBRT SPINE AND NON-SPINE
XII. SBRT MISC. [H/N, RCC, ADRENAL]

CONTACT FOR OFFLINE PHYSICAL CLASS

DR KANHU CHARAN PATRO

MD, DNB (RADIATION ONCOLOGY), MBA, FICRO, FAROI, PDCR, CEPC
HOD, RADIATION ONCOLOGY
Mahatma Gandhi Cancer Hospital and Research Institute, Visakhapatnam, India
drkcpatro@gmail.com /M+91-9160470564

Target delineation class

TRAGET DELINEATION ONE DAY CLASS FOR STUDENTS (8 Hours)

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II. NON-GLIOMA
III. H/N- NODAL
IV. LUNG
V. BREAST
VI. ESOPHAGUS
VII. HPB
VIII. RECTUM
IX. PELVIC NODAL
X. CERVIX
XI. PROSTATE
XII. SARCOMA

CONTACT FOR OFFLINE PHYSICAL CLASS

DR KANHU CHARAN PATRO

MD, DNB (RADIATION ONCOLOGY), MBA, FICRO, FAROI, PDCR, CEPC

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One day Radiology refresher course for oncologists

Chapters

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2. Radiology of brain-1 1/2hr
3. Radiology of skull base-1 hr.
4. Radiology of neck-1 1/2hr
5. Radiology of thorax-1 1/2hr
6. Radiology of abdomen and pelvis-1 1/2hr

CONTACT FOR OFFLINE PHYSICAL CLASS

DR KANHU CHARAN PATRO

MD, DNB (RADIATION ONCOLOGY), MBA, FICRO, FAROI, PDCR, CEPC

HOD, RADIATION ONCOLOGY

Mahatma Gandhi Cancer Hospital and Research Institute, Visakhapatnam, India

drkcpatro@gmail.com /M+91-9160470564

Neuro-Oncology Class

NEURO-ONCOLOGY ONE DAY CLASS FOR STUDENTS (8 Hours)

BY DR KANHU CHARAN PATRO

I. Brain tumor WHO classification 2021
II. CT-MR neuro-anatomay [brain and spine]
III. Neuroimaging for stereotaxy
IV. Radiology of brain tumors
V. Management of glial tumors
VI. Management of non-glial tumor
VII. Target delineation of glioma
VIII. Target delineation of non glioma lesions
IX. CSI planning
X. Re-irradiation in brain tumors

CONTACT FOR OFFLINE PHYSICAL CLASS

DR KANHU CHARAN PATRO

MD, DNB (RADIATION ONCOLOGY), MBA, FICRO, FAROI, PDCR, CEPC
HOD, RADIATION ONCOLOGY
Mahatma Gandhi Cancer Hospital and Research Institute, Visakhapatnam, India
drkcpatro@gmail.com /M+91-9160470564


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