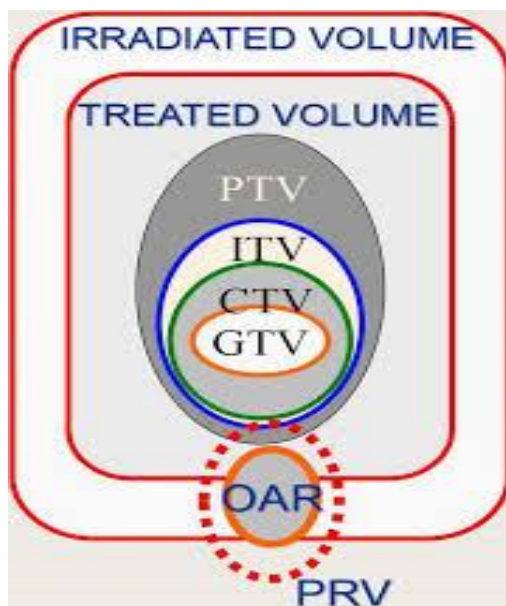
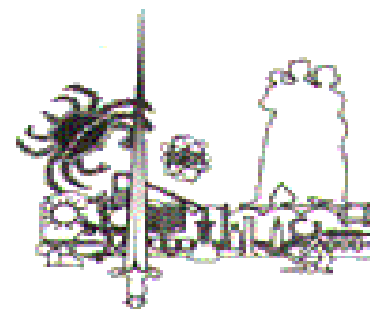


Prescribing, Recording and Reporting Photon Beam Therapy Report 62



Dr. Pooja Nandwani Patel

Associate Professor
Dept. of Radiation Oncology
GCRI, Ahmedabad



INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS (ICRU)

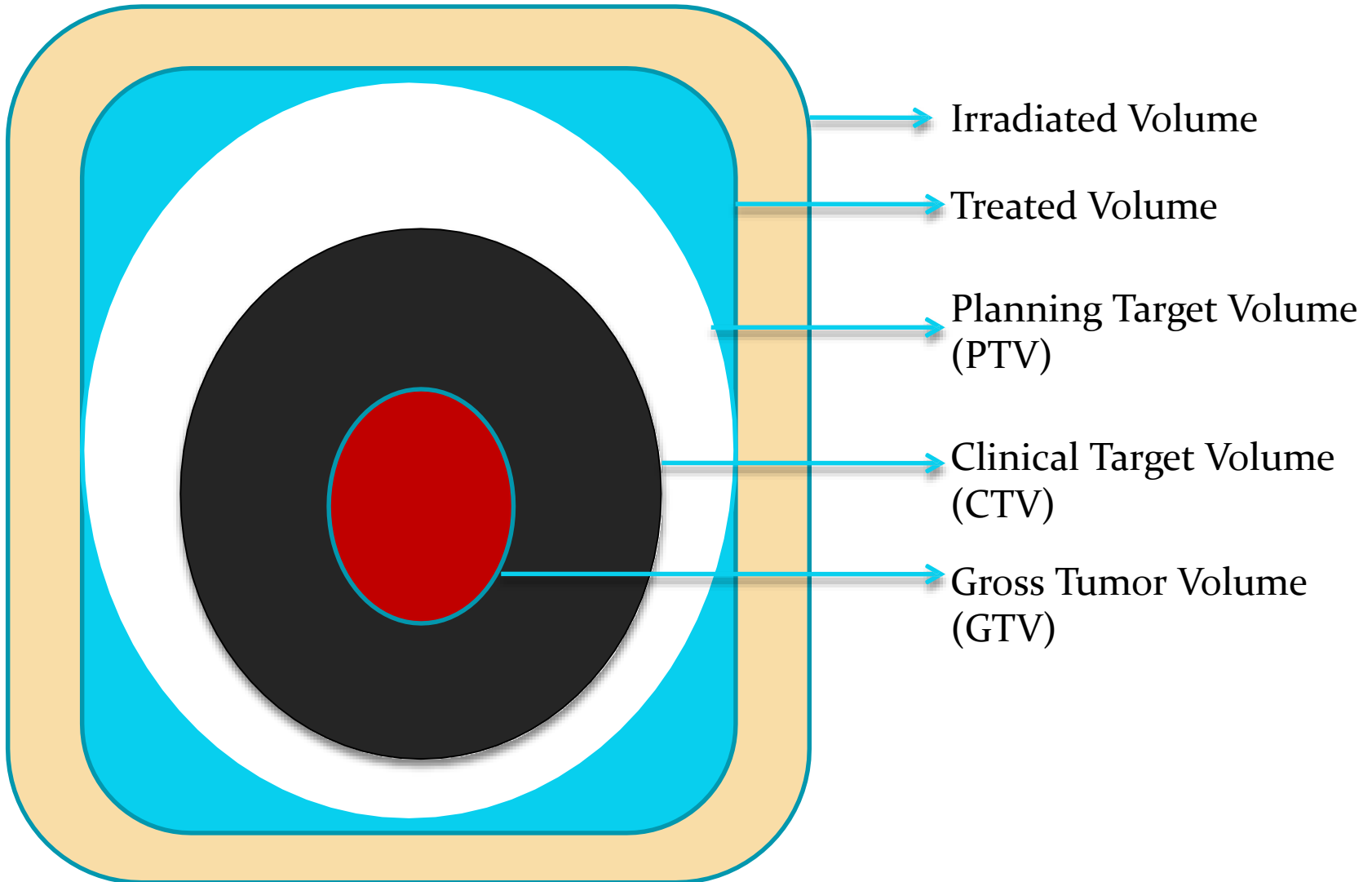
ICRU 29 (1978): 1978

ICRU 50 (1993): 1993 to 1999

ICRU 62 (1999): 1999 to till date

ICRU 83 (2010): 2010 on wards

ICRU 50



ICRU 50

Volumes defined prior to treatment planning :

- Gross Tumor Volume (GTV)
- Clinical Target Volume (CTV)

Volumes defined during the treatment planning :

- Planning target Volume (PTV)
- Organs at risk
- Treated Volume
- Irradiated Volume

ICRU 62 ????

- ICRU 50 - Stimulated broad interest, questions, debates and discussion
- In intervening years, irradiation techniques have advanced
- Development of conformal therapy and expected therapeutic gain as well as geometric miss
- Probability of Benefit versus Risk of complications



Formulated need for 62, supplement to 50

- Define additional concepts and formulate more accurate definitions facilitating exchange of scientific and clinical information

Justify update of ICRU 50 !!!

- 1. Improvements in staging and imaging procedures
- 2. improvements in delivery of precision RT techniques
- 3. advances in our understanding of normal tissue response
- In intervening years, irradiation techniques have advanced

**Prescribing, Recording and
Reporting Photon Beam
Therapy (Supplement to
ICRU Report 50)**

1999

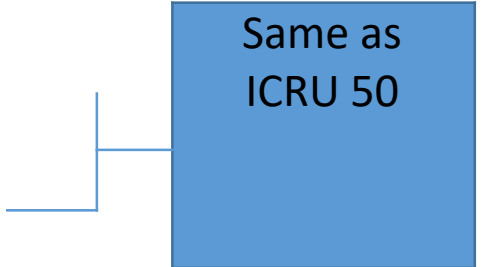


INTERNATIONAL COMMISSION
ON RADIATION UNITS AND
MEASUREMENTS

ICRU 62

Volumes defined prior to treatment planning :

- Gross Tumor Volume (GTV)
- Clinical Target Volume (CTV)



Same as
ICRU 50

Volumes defined during the treatment planning :

- Planning target Volume (PTV)
- Treated Volume
- Irradiated Volume
- Planning Organ at Risk Volume (PRV)
- Conformity Index

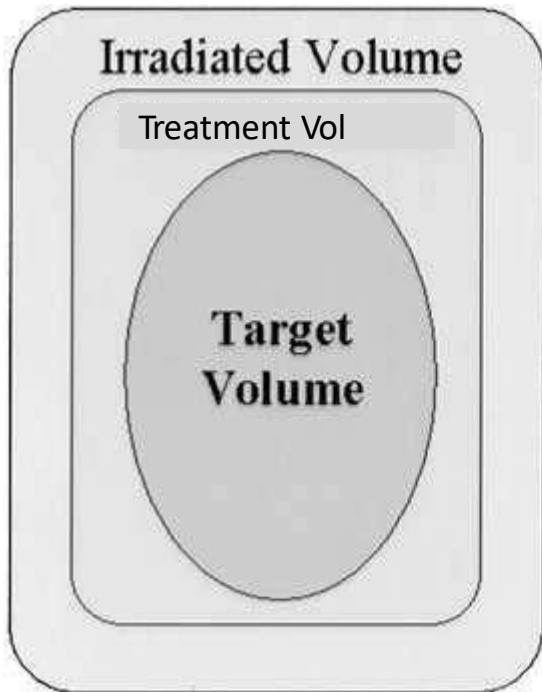
ICRU-62

- Gives more detailed recommendations on the different margins that must be considered to account for anatomical & geometrical variations & uncertainties.
- PTV has been separated into two components: an internal margin and set-up margin.
- Classified organs at risk depending on response to radiation.
- Defined planning organ at risk volume (PRV)
- Report dose to the OAR/PRV
- Introduced conformity index
- Gives recommendations on graphics

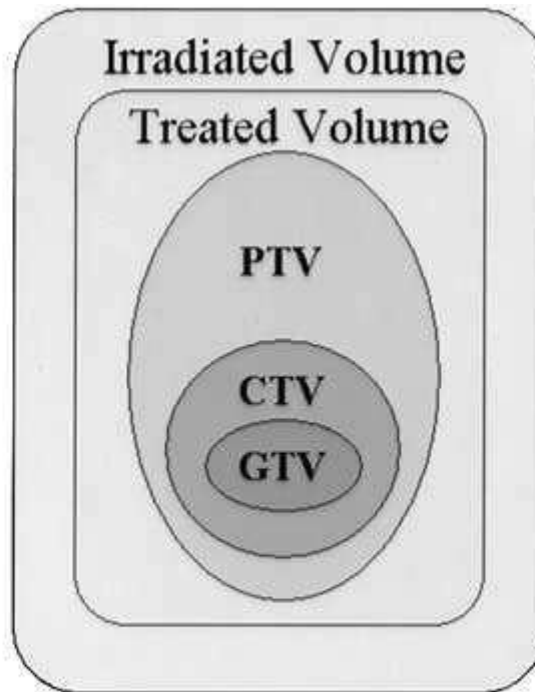
Important remarks

1. Reporting is emphasized- responsibility physician, appropriate exchange of information between centers
2. Level of completeness or complexity in the recommendations for reporting

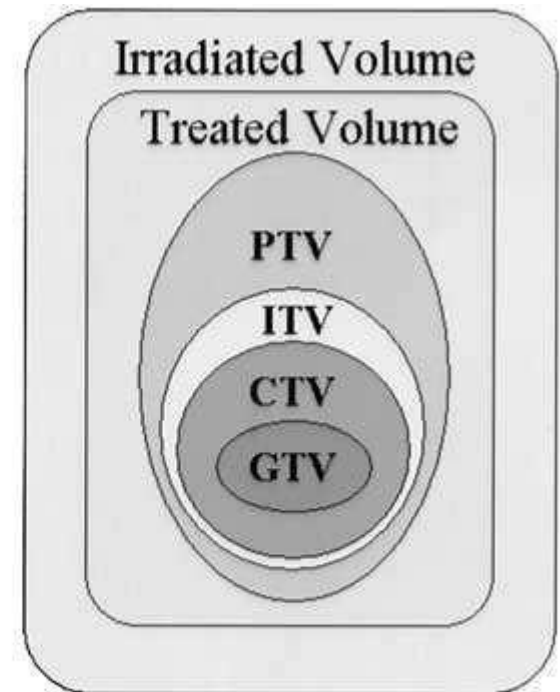
VOLUMES



(A) ICRU 29



(B) ICRU 50



(C) ICRU 62

Coordinate System

- For accurate RT - relate the position of tissue, organ or volume in patient to position and orientation of beam used for both imaging and therapy
- This requires the use of three coordinate systems
 - one within the patient
 - one related to the imaging unit
 - one related to the treatment machine

Reference Points

- Alignment of the patient in a reproducible and stable position is a prerequisite for correct definition of volumes and set-up of beams
- Adequate patient immobilization systems are the most effective means to accomplish this
 - ✓ Internal Reference Points - anatomical landmarks (e.g., bony structures or gas-filled cavities)
 - ✓ External Reference Points - face masks, bite blocks and shells, skin markings or alignment tattoos)

Volumes

Table 1. Summary of the ICRU Nomenclature for Volumes (1970s to Present)

<i>ICRU Report 29: 1970s-1993</i>	<i>ICRU Report 50: 1993-1999 (Present)</i>	<i>ICRU Report 62: 1999-Present</i>
Target volume	GTV CTV PTV	GTV CTV Internal target volume PTV
Treatment volume	Treated volume	Treated volume
Irradiated volume	Irradiated volume	Irradiated volume
Organ at risk	Organ at risk	Organ at risk Planning risk volume
Hot spot hot spot (area outside target that receives dose larger than 100% of specified target dose) (at least 2 cm ² in a section)	Hot spot (volume outside PTV that receives dose larger than 100% of specified PTV dose) (>15 mm diameter)	Hot spot hot spot (volume outside PTV that receives dose larger than 100% of specified PTV dose) (>15 mm diameter)
Dose heterogeneity (no value given)	Dose heterogeneity (+7 to -5% of prescribed dose)	Dose heterogeneity (+7 to -5% of prescribed dose)

INTERNAL MARGIN (IM) AND INTERNAL TARGET VOLUME (ITV)

- It is the margin given around the CTV to compensate for all variations in the site, size and shapes of organs and tissues contained in or adjacent to CTV
- These may result from respiration, different fillings of the bladder and rectum, swallowing, heart beat, movements of bowel etc
- These are physiological variations which are very difficult to control and result in changes in the site, size and shape of CTV

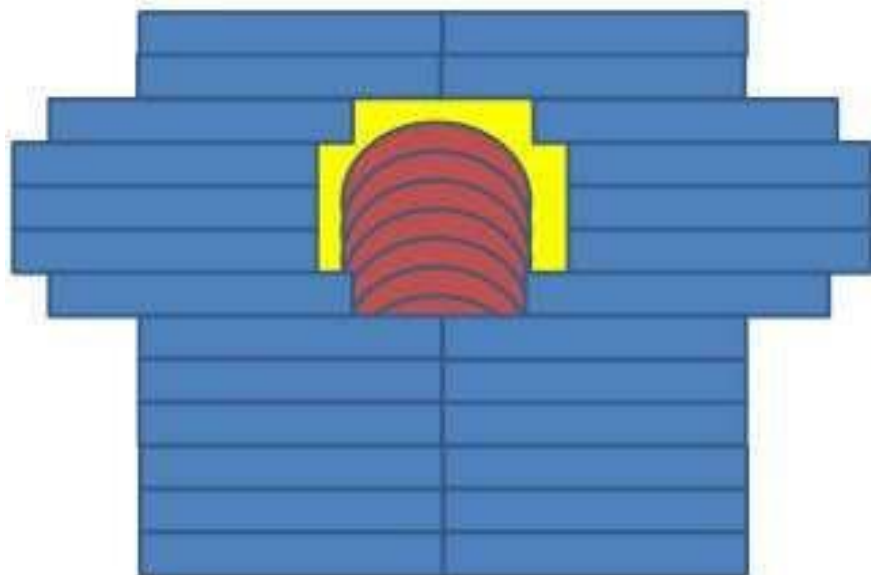
Internal Target Volume (ITV)

- ❑ Consists of the CTV plus an internal margin
- ❑ It is the margin given around the CTV to compensate for all variations in the site, size and shapes of organs and tissues contained in or adjacent to CTV
- ❑ The internal margin is designed to take into account the variations in the size and position of the CTV relative to the patient's reference frame (usually defined by the bony anatomy), i.e., variations due to organ motions such as breathing, bladder or rectal contents, etc

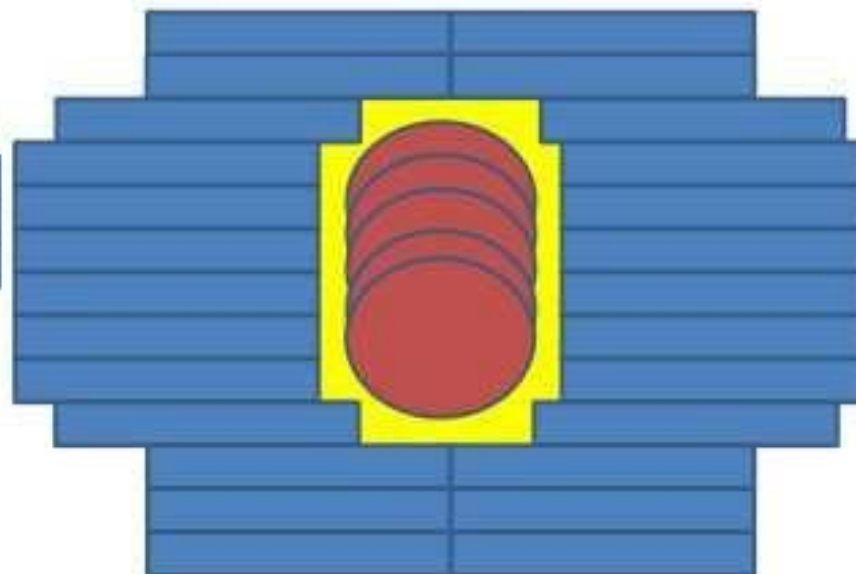
Internal target volume (ITV) = CTV+IM

Motion management during treatment

Standard Treatment

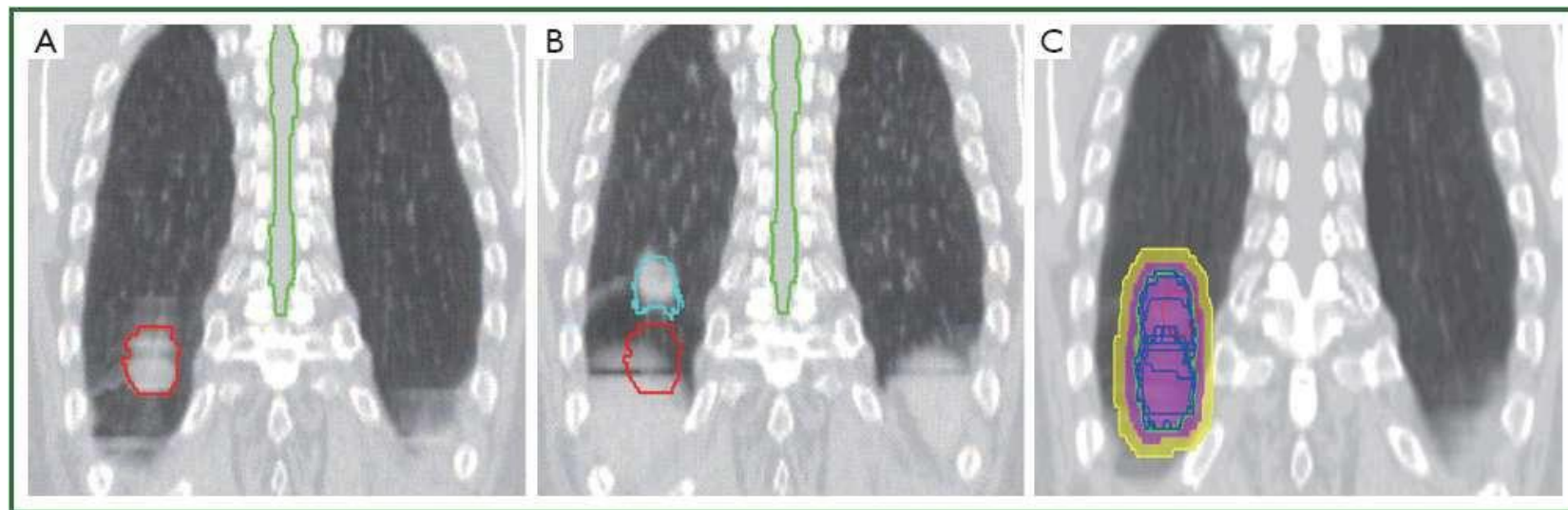


ITV



Internal Target Volume (ITV) approach:

- Treat track of tumor motion
- Based on a 4-D dataset
- Custom margins for each tumor



SET-UP MARGIN (SM)

- There can be many uncertainties (inaccuracies and lack of reproducibility) in patient positioning and alignment of the therapeutic beams during treatment planning and through all treatment sessions.
- These uncertainties depend on factors like :
 - variations in pt. positioning
 - mechanical uncertainties of the equipment (sagging of gantry, collimators, and couch)
 - dosimetric uncertainties
 - transfer set-up errors from CT & simulator to the treatment unit
 - human factors

SET-UP MARGIN (SM) is the margin that must be added to account specifically for uncertainties (inacuracies and lack of reproducibility) in patient positioning and alignment of the therapeutic beams during treatment planning and through all treatment sessions.

$$\text{ITV} = \text{CTV} + \text{IM}$$

$$\text{PTV} = \text{CTV} + \text{combined IM \& SM}$$

PLANNING TARGET VOLUME (PTV) by ICRU 62

- ❑ Introduce the concept of setup margin.
- ❑ Setup margin is the Uncertainty in patient positioning and mechanical uncertainty of the equipment which arise due to sagging of gantry or collimator or couch, Dosimetric uncertainty, transfer setup error , human error, etc.

$$\text{PTV} = \text{CTV} + \text{IM} + \text{SM}$$

SYSTEMATIC AND RANDOM ERRORS

- **Systematic errors** – treatment preparation errors (influence all fractions) like full rectum
- **Random errors** – treatment execution errors (influence only the single fraction) like positioning

**Intra# variation
during single #**

**Inter# variation
during entire course**

Category

Random

Systemic

Random

Systemic

Variations of CTV

In size

Physiological processes
(circulation, respiration,
peristalsis)

Physiological processes
(circulation)

Physiological processes
(e.g., degree of bladder
filling, bowel gas)

Tumor reduction or
swelling

In position relative to a
fixed point in the
patient

Physiological processes
(circulation, respiration,
peristalsis)

Change in treatment
position (prone-supine)

Physiological processes
(e.g., degree of filling of
cavities)

Weight loss

Variations in position of
the patient relative to
the treatment beams

Patient movements

Daily set-up

Technical errors

CONFORMITY INDEX (CI)

- It is defined as the quotient of the Treated Volume and the volume of PTV
- Can be employed when the PTV is fully enclosed by the TV, then it is the quotient of the TV and the volume of the PTV
- $CI = TV/PTV$
- It can be used as a part of the optimization procedure

Revising Irradiated Volume and Treated Volume

- Size of the Irradiated Volume relative to the Treated Volume may increase as the number of beam directions increases
- Implies a compromise so thus it is the responsibility of the radiation oncology team to select what is judged to be the optimal treatment.
- In "conformal therapy" using beam shaping, e.g., by MLC (Multi Leaf Collimator), or customized blockings, both Treated Volume and Irradiated Volume can be reduced.

PLANNING ORGAN AT RISK VOLUME (PRV)

- This is a volume which gives into consideration the movement of the Organs at Risk during the treatment
- An integrated margin must be added to the Organ at Risk to compensate for the variations and uncertainties, using the same principle as PTV and is known as the Planning Organ at Risk volume (PRV)
- A PTV and PRV may occasionally overlap

VOLUME/MARGIN

REFERENCE POINT AND COORDINATE SYSTEM (1)

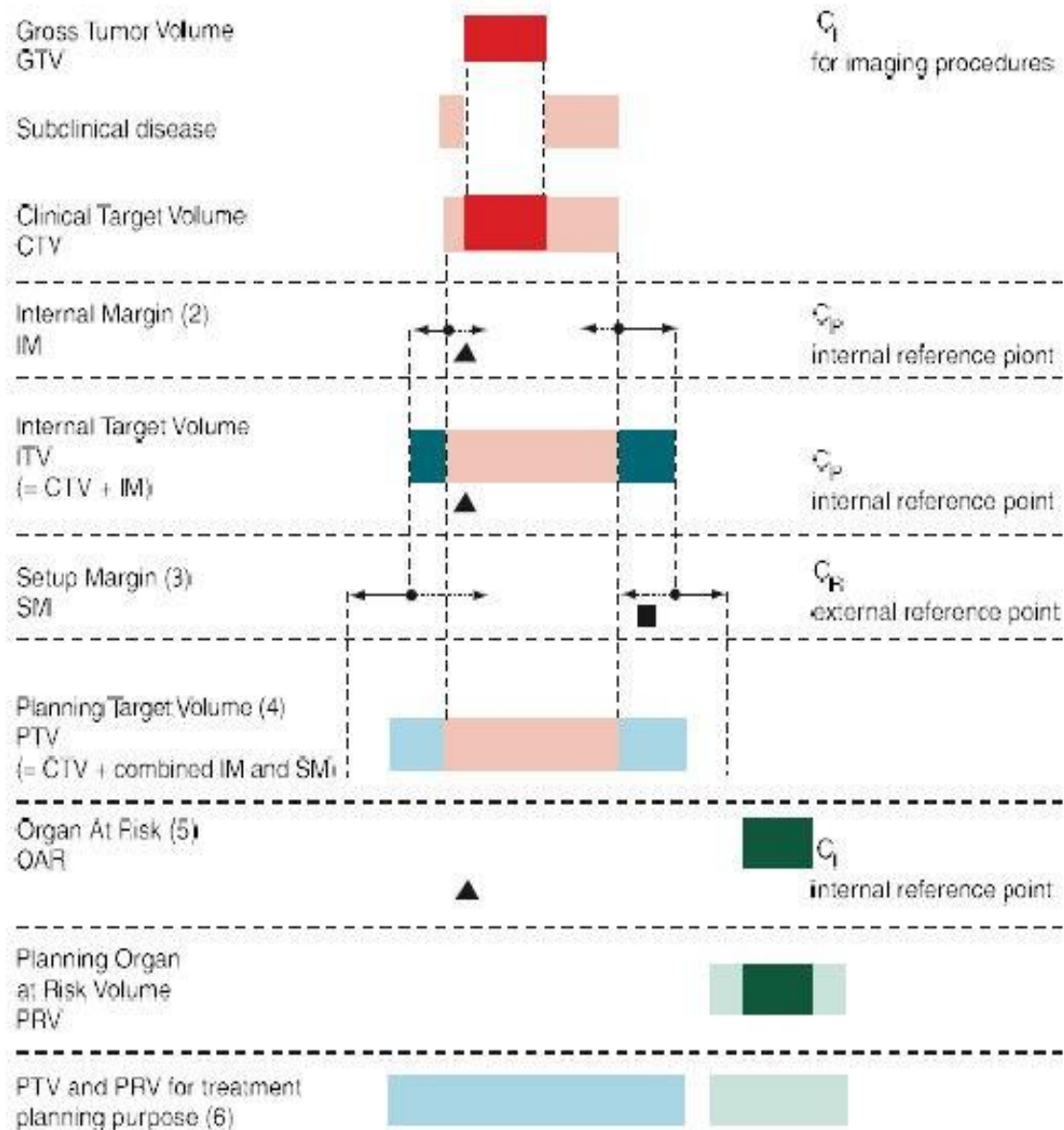
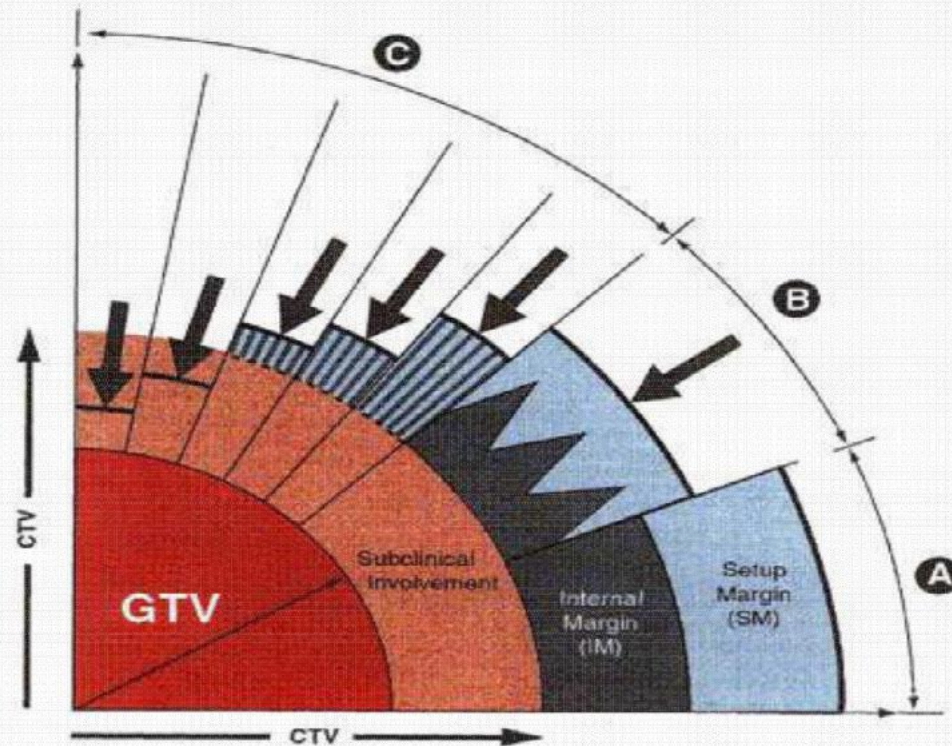


Fig.3.21 Treatment volumes according to the ICRU-62 report

ICRU 62 Definitions

Prescribing, Recording and Reporting Photon Beam Therapy (Supplement to ICRU Report 50)



The arrow illustrates the influence of the organs at risk on delineation of the PTV (thick, full line).

- Gross Tumor Volume (GTV)
- Subclinical Involvement
- Internal Margin (IM)
- Set Up Margin (SM)

ICRU Report 62, 1999

GRAPHICS

- ❑ These are used to delineate the different volumes and the other landmarks
- ❑ These are in different colors for an easy and uniform interpretation
- ❑ The convention recommended and used in ICRU 62 are:

GTV - Dark Red

CTV – Light Red

ITV – Dark Blue

PTV – Light Blue

OR – Dark Green

PRV – Light Green

Landmarks - Black

ABSORBED DOSE DISTRIBUTION

- The dose given to the tumor should be as homogenous as possible
- In cases of heterogeneity of doses, the outcome of the treatment cannot be related to the dose. Also, the comparison between different patient series becomes difficult
- However, even if a perfectly homogenous dose distribution is desirable, some heterogeneity is accepted due to technical reasons

The heterogeneity should be foreseen while prescribing a treatment, and, in the best technical and clinical conditions should be kept within +7% and -5% of prescribed dose

(Wittkamper et al., Brahme et al., Mijnheer et al.).

Recommendations for Reporting

AIM

- Promote uniformity between radiotherapy centres
- Exchange information
- Use same terminology and definitions
- Deals with volumes and doses
- Valid for photon beam therapy

DOSE REPORTING

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

➤ Doses reported are :

- Dose at ICRU reference point
- Minimum dose to PTV
- Maximum dose to PTV
- Mean dose to PTV
- Modal dose
- Median dose

ORGANS AT RISK (OAR)

ICRU 50

- These are normal tissues whose radiation sensitivity may significantly influence the treatment planning and/or prescribed dose.
- They may be divided into 3 classes :
 1. Class I : Radiation lesions are fatal or result in severe morbidity
 2. Class II : Radiation lesions result in mild to moderate morbidity
 3. Class III : Radiation lesions are mild, transient, and reversible, or result in no significant morbidity

CLASSIFICATION OF ORGANS AT RISK

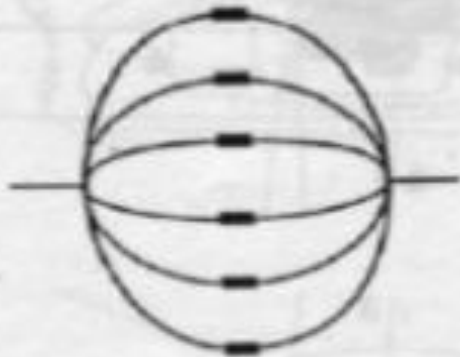
- Classified as :
 - ✓ **Serial** – whole organ is a continuous unit and damage at one point will cause complete damage of the organ (**spinal cord, digestive system**). So even point dose is significant
 - ✓ **Parallel** – organ consists of several functional units and if one part is damaged, the rest of the organ makes up for the loss (**lung, bladder**). Dose delivered to a given volume or average/mean dose is considered
 - ✓ **Serial-parallel** – **kidney** (glomerulus- parallel, tubules-serial), **heart** (myocardium- parallel, coronary arteries-serial).



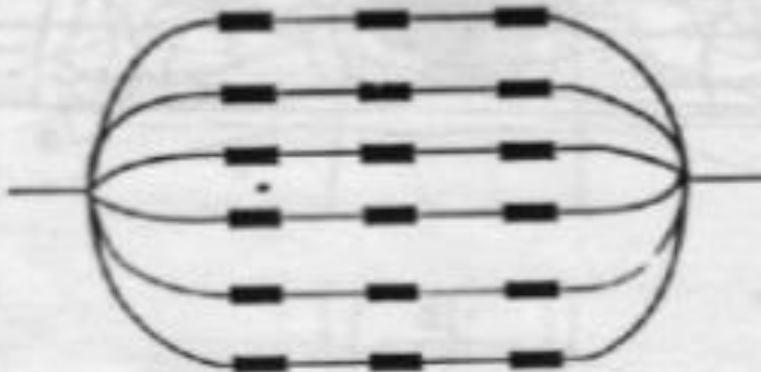
(a)



(b)



(c)



(d)



ORGANS AT RISK

- According to the functional models based on the FSU (Functional Sub Unit) concept [*Withers et al.*, *Kallman et al.*, and *Olsen et al.*] for the purpose of evaluation of the volume-fractionation-response, the tissues of an Organ at Risk are considered to be functionally either serial, parallel or serial-parallel structures
- eg : Spinal cord has a high relative seriality meaning that a dose above tolerance limit to even small volume of this OR may be deleterious. On the other hand, Lung has a low relative seriality meaning that the most important parameter is the relative size of volume that is irradiated above tolerance level

Three levels of Dose Reporting ICRU 50

- Level 1: Basic Techniques : This basic level may sometimes be sufficient in any center when simple treatments are performed
- Level 2: Advanced Techniques: At this level, it is assumed that the GTV, CTV, and PTV can be defined
- Level 3: Developmental Techniques: At this level, 3-D dose computation of any beam arrangement (such as non-coplanar beams) and dose/volume histograms are available.

- The 3 levels of reporting could be described as follows:
 - Level 1: Only the dose at the Reference Point and its variation along a central beam axis is available
 - Level 2: The dose distribution can be computed for plane(s)
 - Level 3: The dose distribution can be computed for volumes

At any level, the dose at the ICRU Reference Point and the best estimation of the maximum and the minimum dose to the PTV should be reported.

Recommendation: Reporting at least from level 2 but at same time reporting of all basic parameter of level 1 is must

Additional information which is considered as relevant should also be added. This could be related to :

- a more accurate and detailed description of dose distribution e.g., average dose and its standard deviation, dose - volume histograms (DVH) etc
- an accurate description of the dose at different anatomical sites (including Organs at Risk)

- Note- ICRU Reports 50 and 62 do not make strict recommendations regarding dose prescription; rather ICRU states that the *radiation oncologist should have the freedom to prescribe the parameters in his/her own way, mainly using what is current practice to produce an expected clinical outcome of the treatment*
- Reporting these additional information ultimately contributes to the developments and improvements in Radiotherapy

CONCLUSIONS

- Proper identification and delineation of GTV is the most important factor in treatment
- Other volumes like CTV, PTV, ITV should also be properly delineated
- The errors like set-up error and human errors should be kept to a minimum
- Dose prescription, fractionation and calculation should be done in the same way by all different centers throughout the world for the proper exchange of information and reporting

- ICRU Report 62 literally emphasizes prescribing recording and reporting of photon beam therapy
- Authenticate 50 and is supplement to it
- Gives special attention for the level of completeness and complexity required in recommendations of reporting
- Prescription of treatment is chief responsibility of RO

IRRADIATED VOLUME

TREATED VOLUME

PTV

Thank you

OAR

PRV

