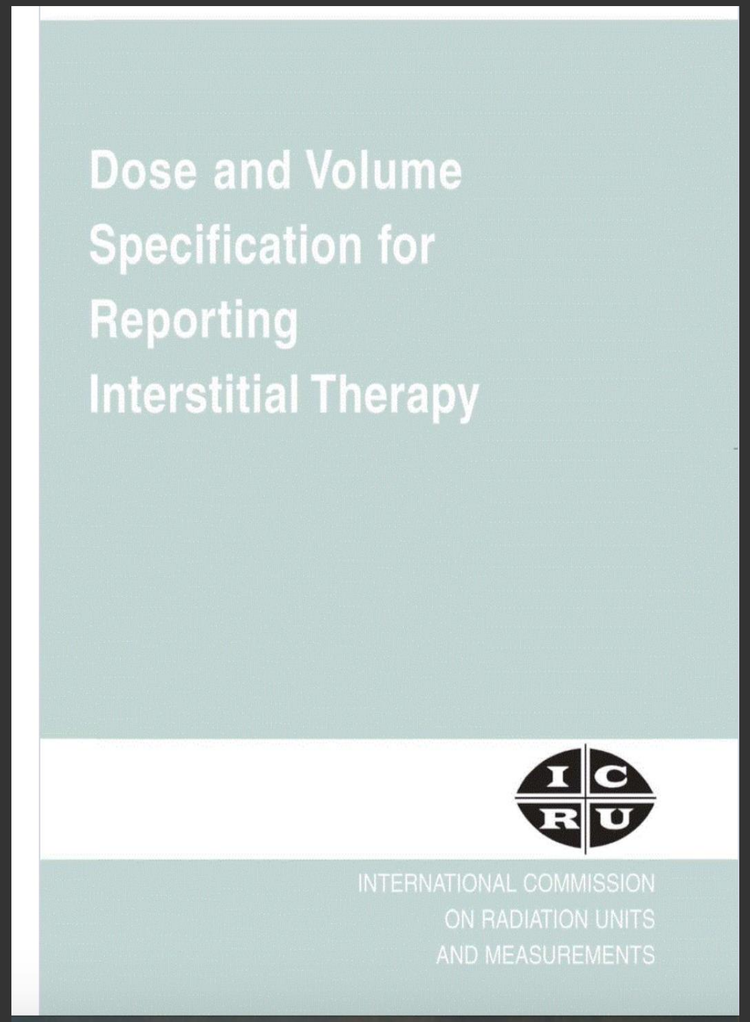
ICRU 58
Dose and Volume Specification For Reporting Interstitial Therapy



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INTRODUCTION

Introduction of –

- miniaturized brachytherapy sources,
- sophisticated 3-D source localization methods,
- these can be linked to computerized methods for dose calculation.

Therefore, a common language is valuable to provide a method of dose specification and reporting which can be used for implants of all types of interstitial brachytherapy procedures.

1985: ICRU Report 38,

Dose and volume specification
and
Reporting intracavitary Brachytherapy in GYN.

1997: ICRU Report 58,

Aim-- To generate a guideline about the dose and volumes specification for reporting interstitial Brachytherapy.

ICRU 58

Aim:

To develop a common language based on existing Concepts.

1. usable to describe what has been done.
2. closely related to the outcome of the treatment.
3. generally understood.

Consistency with external beam radiotherapy (EBT)

- **D**efinition of volumes – the same.
- ICRU reference point for dosimetry in EBRT – cannot be taken over directly for interstitial BT.

ICRU 58

Historic systems of prescribing brachytherapy

- Manchester system
- Paris system
- Quimby system

ICRU 58

- What is meant by term “system” ?

- It denotes a set of rules which takes into account the
- Source types ,
- Strengths,
- Geometry
- Method of application to obtain suitable dose distributions over the volume(s) to be treated and
- Provides a means of calculating and specifying dose.

While an implant may follow the source distribution rules of a system, it does not comply with the system unless the method of dose specification and prescription are also followed.

Definition of Terms and Concepts

ICRU

Two important type of implants in ICRU 58 are,

1. Temporary implant
2. Permanent implant

ICRU 58

Temporary Implant

- The radioactive sources are removed from the tissue after the treatment is completed.
- Radionuclide used have typically longer half life.

Permanent Implant

- The brachytherapy sources remain in the tissues, and they will not be removed.
- Radionuclide used have typically shorter half life.

ICRU 58

Traditionally,

Temporary implant – sources are linear (wire like) radioactive sources or seeds arranged in a linear fashion (i.e. ribbons, etc.).

Permanent implants-- multiple point sources distributed in random orientations.

ICRU 58

With the design of the low energy radioactive sources in the form of stranded seeds or radioactive wires, now the permanent implant can also be performed with linear or prearranged ribbons.
The loose seed implants are considered separately in this report.

For Planning permanent implants

The number of sources depends on,

a. Their initial strength.

b. Type of the radioisotope.

For Planning temporary implants

The total time of implantation depends on,

a. Number of sources

b. Strengths and source

c. Pattern of distribution of sources

Improvements of dose distribution is possible through manipulation of the dwell time of some sources in the temporary implant.

Planning boost ---

permanent and temporary implants,
the number of seeds and the initial activity of the seeds are adjusted upon the external beam radiation dose.

Planning boost ---

In external therapy, the two steps—
clinical target volume localization and treatment planning
can always be dissociated and therefore checked separately.

However, in Interstitial Therapy-
the clinical target volume is sometimes decided upon
by the clinician at the time of implantation,
on the assumption that it is contained within the minimum target isodose

KERMA (Kinetic Energy Released in Matter)

The sum of the initial kinetic energie of all the ionizing charged particles liberated by uncharged ionizing particles.

$K = dEtr/ dm$

ABSORBED DOSE

The mean energy imparted by radiation to a unit mass of medium

$D=dE/dm$

1Gy = 1J/Kg

Reference Air Kerma rate

Reference Air Kerma Rate = Air Kerma Rate at a reference point of 1 cm or 1 m.

OR

It is defined as the air kerma rate measured at one meter along the perpendicular bisector of the long axis of the source,corrected for air attenuation and scattering.

Unit : 1 U = μGy/h

The term m^2 is not included inthe unit,since it is inherent in the definition itself.

Total Reference Air Kerma (TRAK)

$$TRAK = \Sigma ti \,.\, Si$$

Where;

Si = Reference air kerma rate for each source.
ti = Irradiation time for each source.

TRAK Does not allow one to derive, even approximately, the absorbed dose in the immediate vicinity of the sources *(i.e.* in the tumor or target volume).

Description of Source Patterns

Description of Source Patterns

The Term " Volume Implant" should not be used

Single plane: An implant containing two or more sources, in the same plane.

Two-plane (double-plane): implant contains two planes, which are generally parallel to each other.

Multi-plane: implant, contains three or more planes.

No planes Recognised : sphere or cylinder.

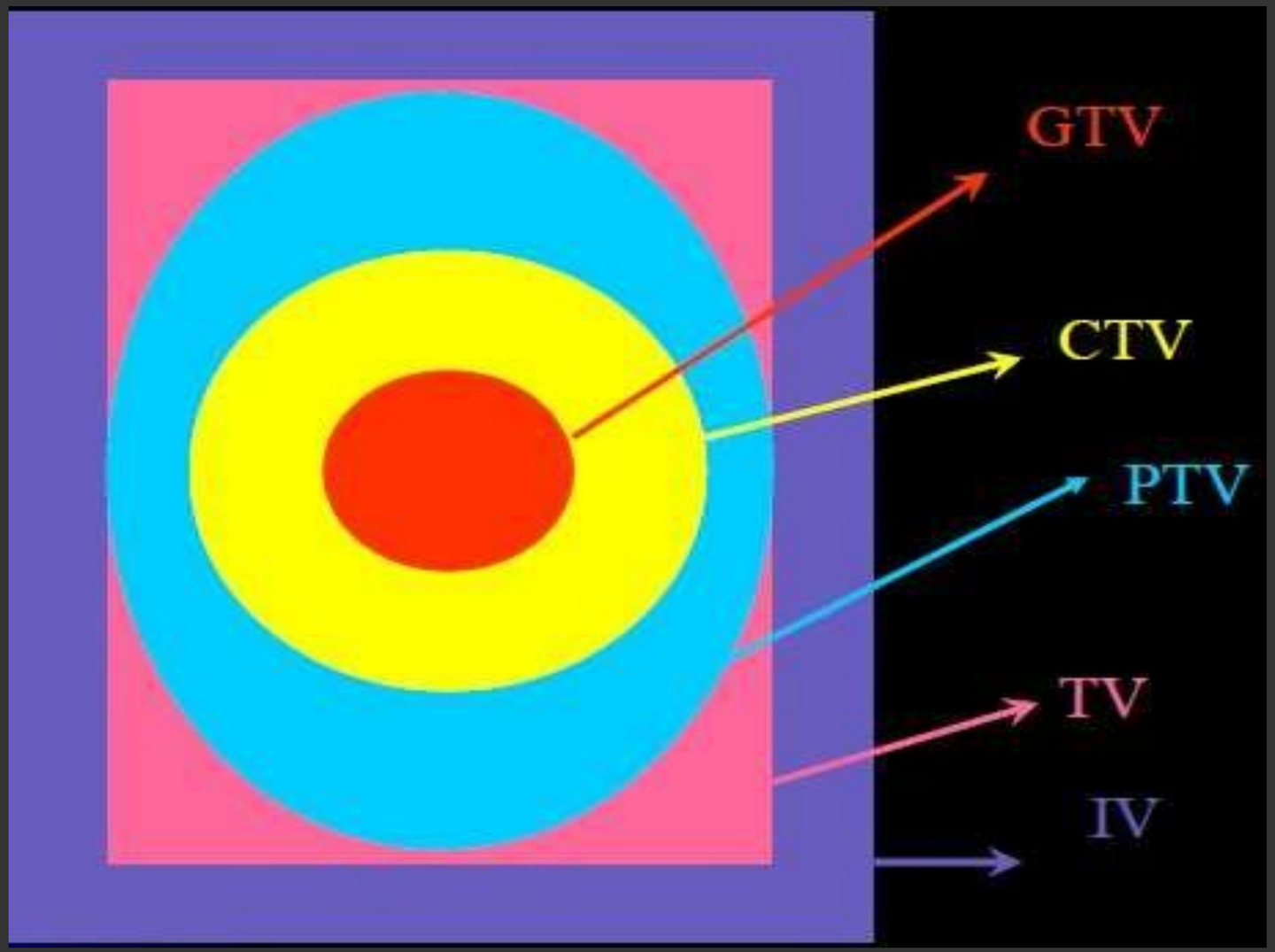
: described by the location of the sources relative to

a plane passing through the centre of the implant

Description of Source Patterns

Planes

VOLUMES



(Gross Tumor volume)

(Clinical Target Volume)

(Planning Target Volume)

(Treatment Volume)

(Irradiated Volume)

Gross Tumor Volume (GTV)

The palpable or visible extent and location of the malignant growth.

There is no gross tumor volume after ------

- **complete "gross" surgical resection.**
- **there are only a few individual cells or "subclinical" involvement (even histologically proven).**

Clinical Target Volume (CTV)

The volume of the tissue that contains a gross tumor volume and/or subclinical microscopic malignant disease which has to be eliminated.

RECOMMENDATIONS__

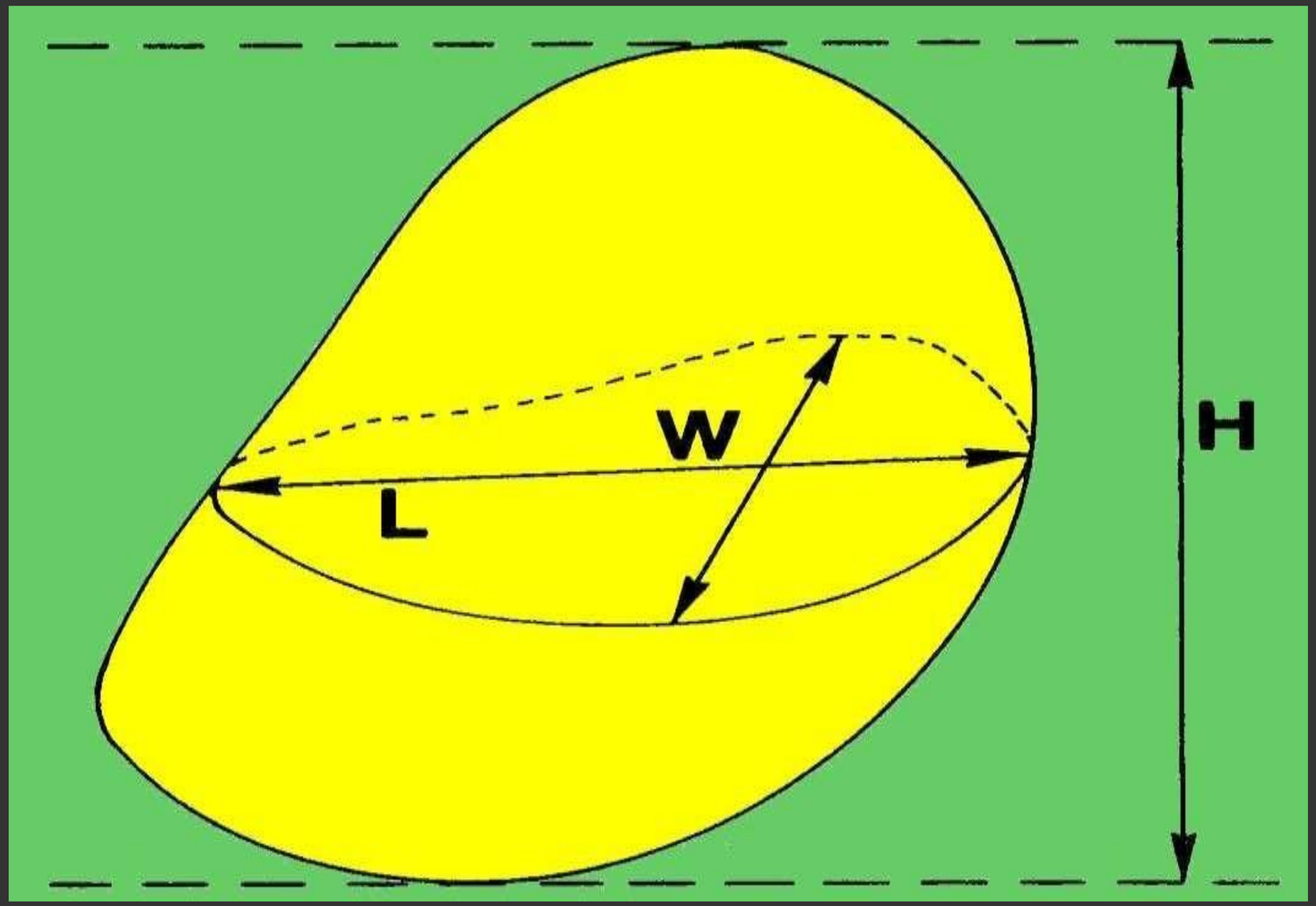
CTV to be described --

- **independently of the dose distribution,**
- **in terms of the patient's anatomy and**
- **the tumor volume.**

The CTV is a tissue volume intended to be irradiated according to a specified dose-time pattern

CTV

The maximum diameters measured in three orthogonal directions must be reported.



Planning Target Volume (PTV)

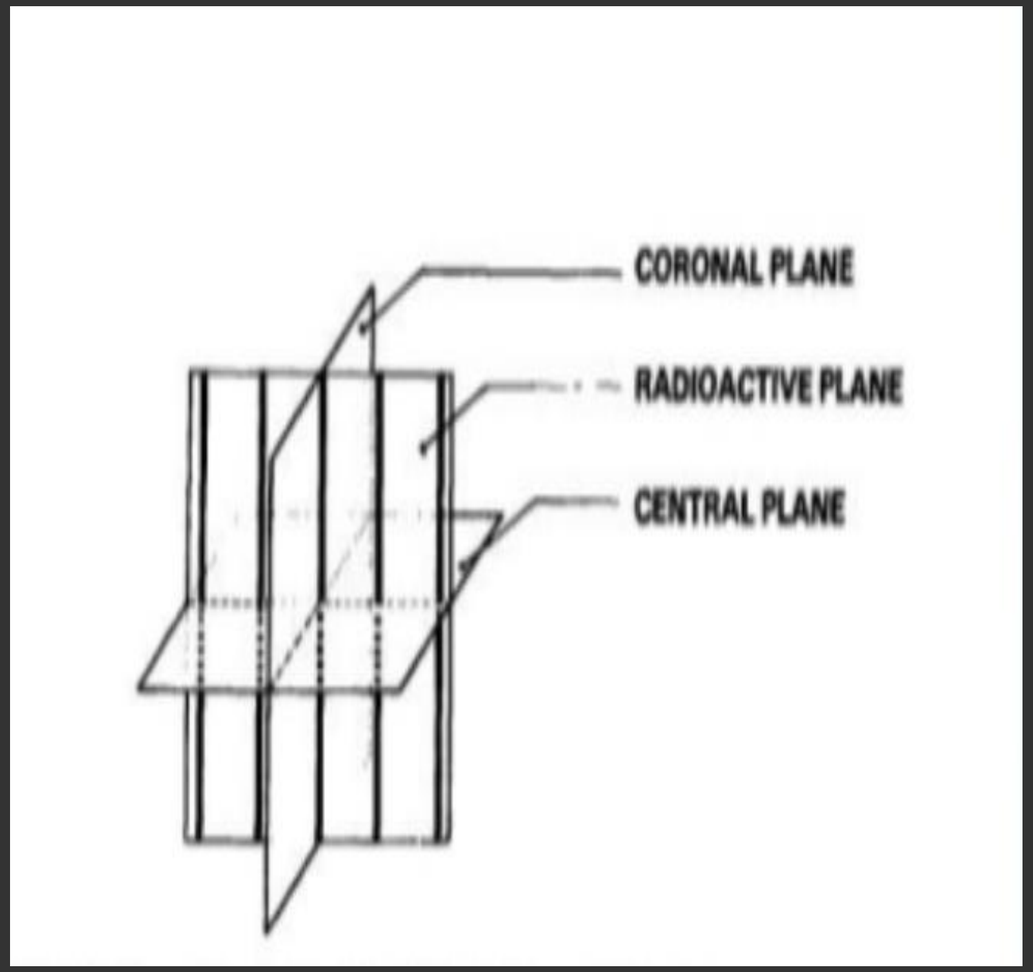
The volume of tissue receiving the prescribed irradiation.

For an interstitial brachytherapy, the PTV is, in general, identical to the CTV.

Treated Volume (TV)

- That volume of tissue, based upon the implant as actually achieved
- The volume of tissue, which is encompassed by an isodose surface that has been specified by the radiation oncologist.
- The dose value at this isodose surface is the minimum target dose

Some terms



Planes of an implant in relation to parallel sources

The Plane formed by the parallel sources—
-**radioactive plane**

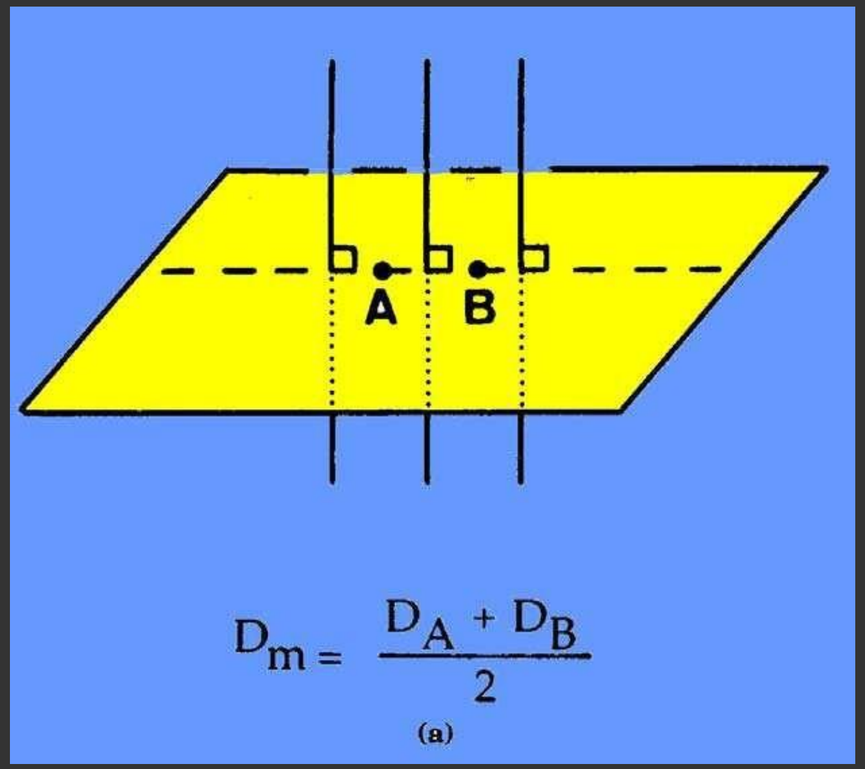
The centre of the Radioactive Plane is called as the—
Centre of the implant

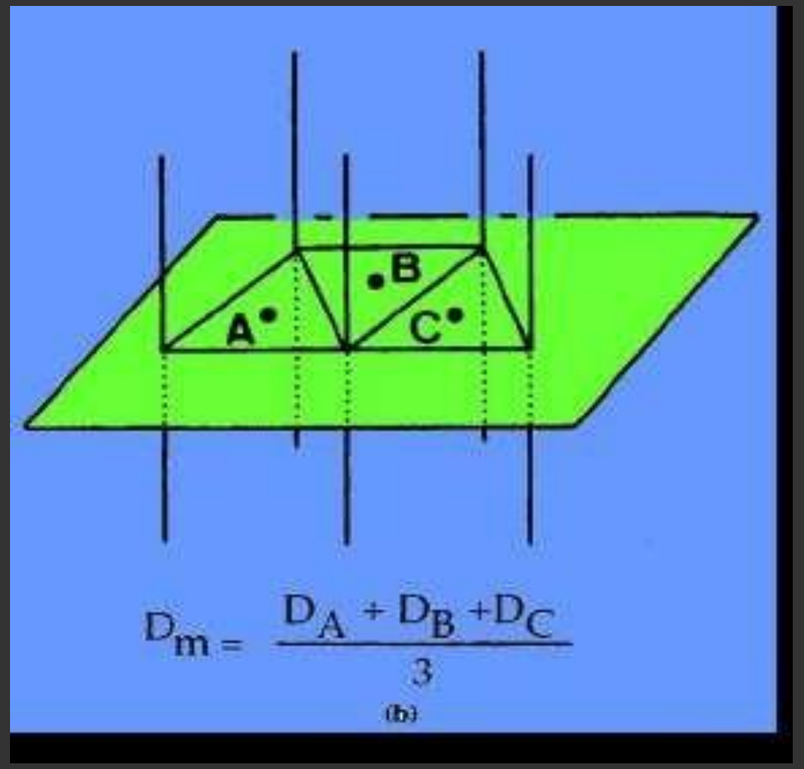
The Central Plane through this point is located at right angles to the needles and thus at right angles to the radioactive plane

A third Plane parallel to the sources and at right angles to the radioactive plane -- **coronal plane**

CENTRAL PLANE

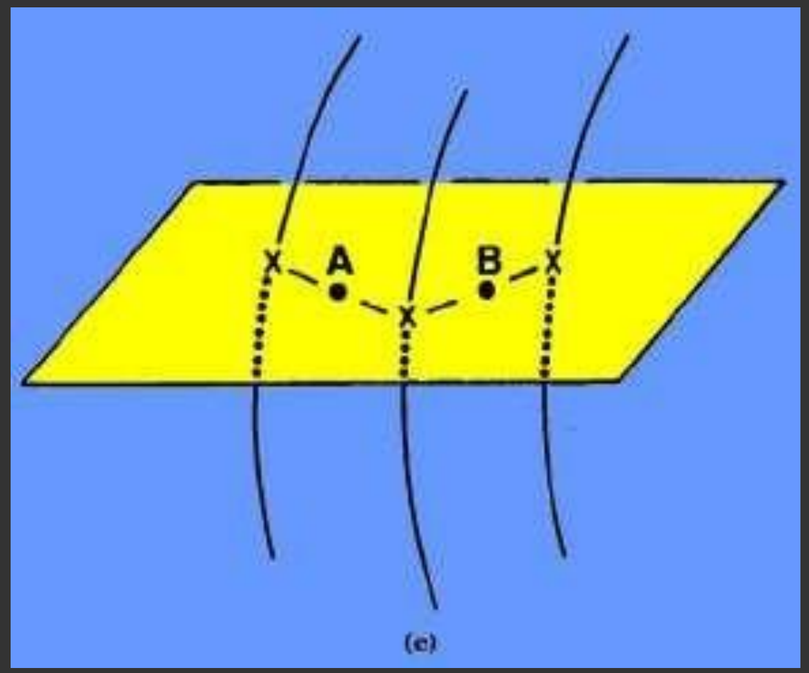
The plane that is perpendicular to the main direction of the linear sources and passing through the estimated center of the implant.

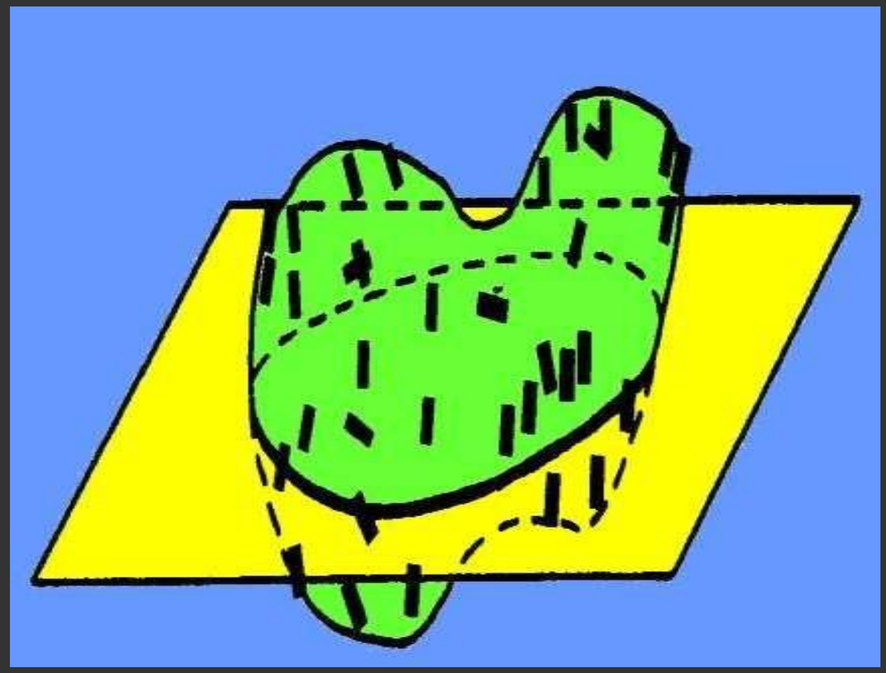




CENTRAL PLANE

For more complex implants, it may be necessary to subdivide the target volume into two or more subvolumes for dose evaluation. Hence a central plane may be defined for each of these subvolumes





Description of Dose Distribution

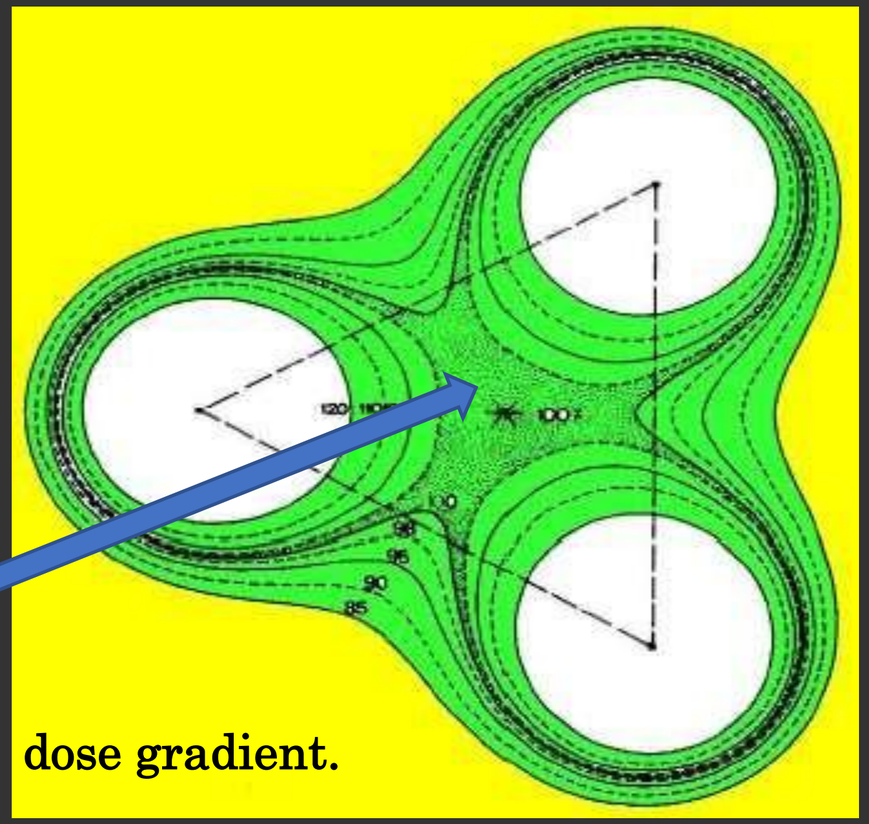
Description of Dose Distribution

General concepts of Implants:

1. Non Homogeneous dose Distribution .
2. Steep dose gradients
3. High Regions around Sources.

   4 Regions of plateau dose or **local minimum doses within the implant volume.**

The dose distribution in a plane perpendicular to linear and parallel sources,



shows a plateau dose region of low dose gradient.

In this example of three sources of 6 cm long and with 1.5 cm spacing, the dose varies by less than 2% between the sources.

Dose Distribution in One or More Planes through the Implant

1.The minimum information needed for the dose distribution of an implant is,

- The isodose curves in at least one chosen plane
- Dose distribution represented either in tabular form or by graphical presentation (ICRU 42)

2.The central plane of the implant should be used, **if only one plane is chosen for isodose calculation.**

3. In order to assess the dose distribution in other areas of the implant, multiple planes for isodose calculation can be chosen, either parallel or perpendicular to the central plane.

Prescribed Dose

Definition-- The dose, which the physician intends to give, and enters in the patient's treatment chart.

Minimum Target Dose (MTD):

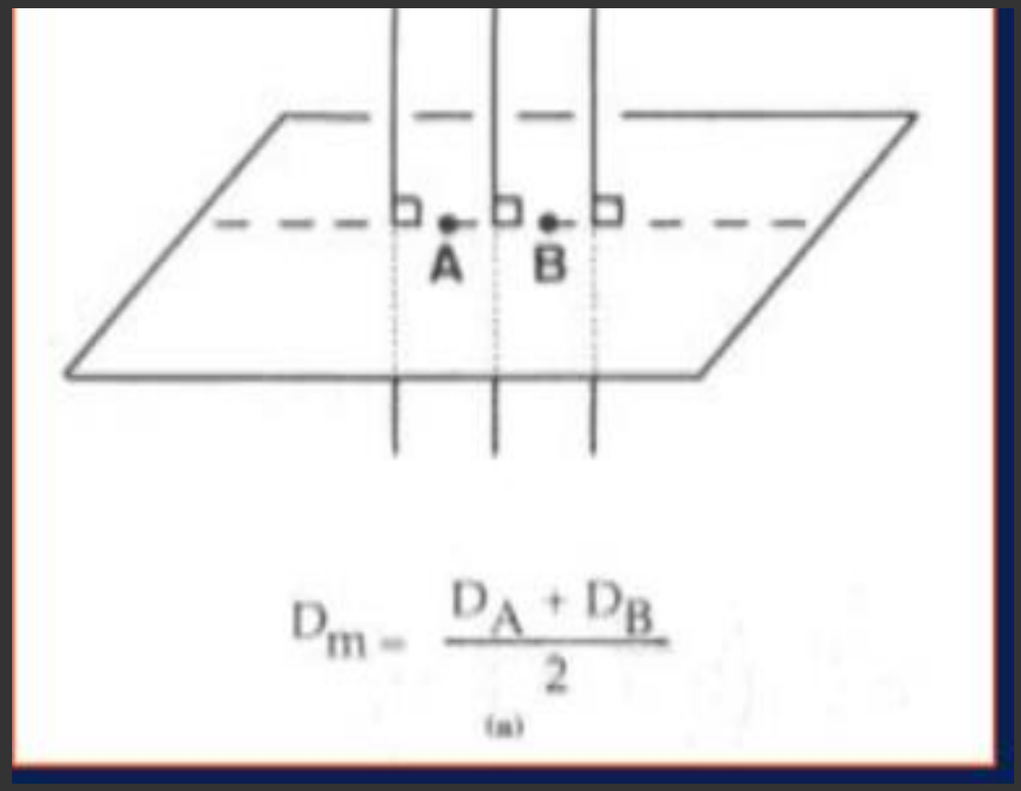
- The minimum dose at the periphery of the CTV
- This must be equal to the Minimum dose decided upon by the clinician as adequate to treat the CTV
- MTD≅ 90% of the prescribed dose in the Manchsteer system for interstitial therapy.

MTD –is known as the REFERENCE DOSE in the Paris system

Prescribed Dose-- Mean Central Dose (MCD) Single Plane : Dm

The Arithmetic mean of the local minimum doses between sources, in the central planes.

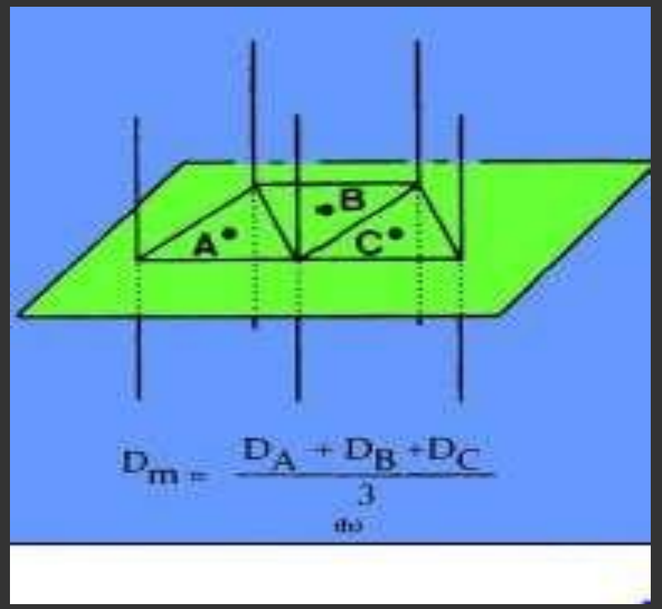
- Assume implant of line sources in parallel - this could also be the catheters for a stepping HDR source
- Calculate dose distribution in plane orthogonal to the source lines
- Calculate dose between lines
- Dm=Mean Central Dose



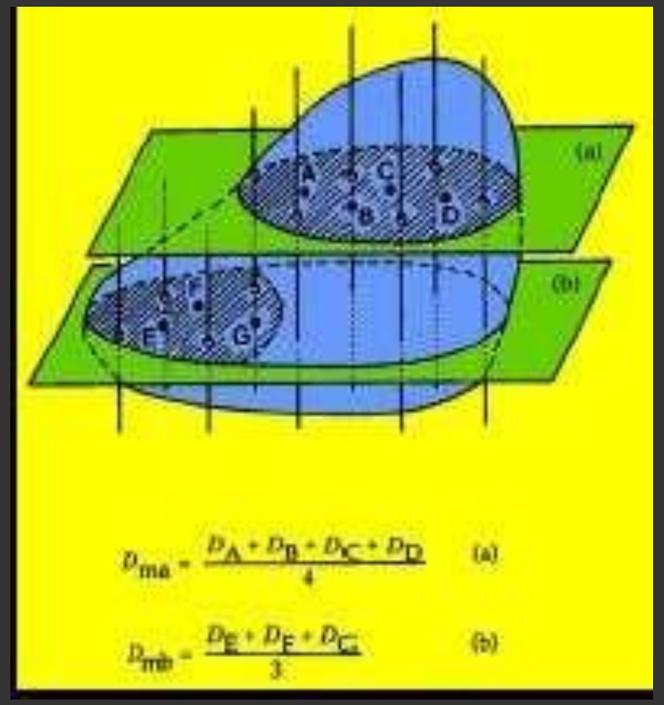
Single plane implant

Prescription Dose Mean Central Dose (MCD) Multi plane : Dm

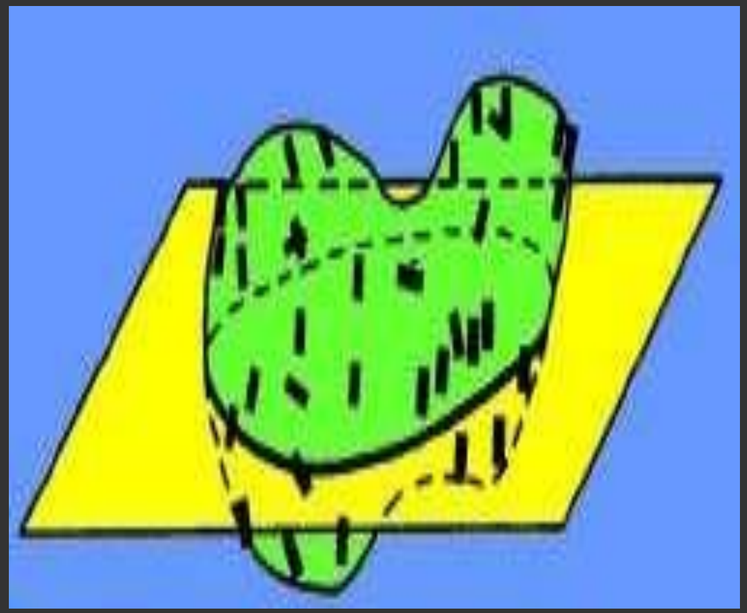
The Arithmetic mean of the local minimum doses between each set of three adjacent source lines within the source pattern.



a two plane implant

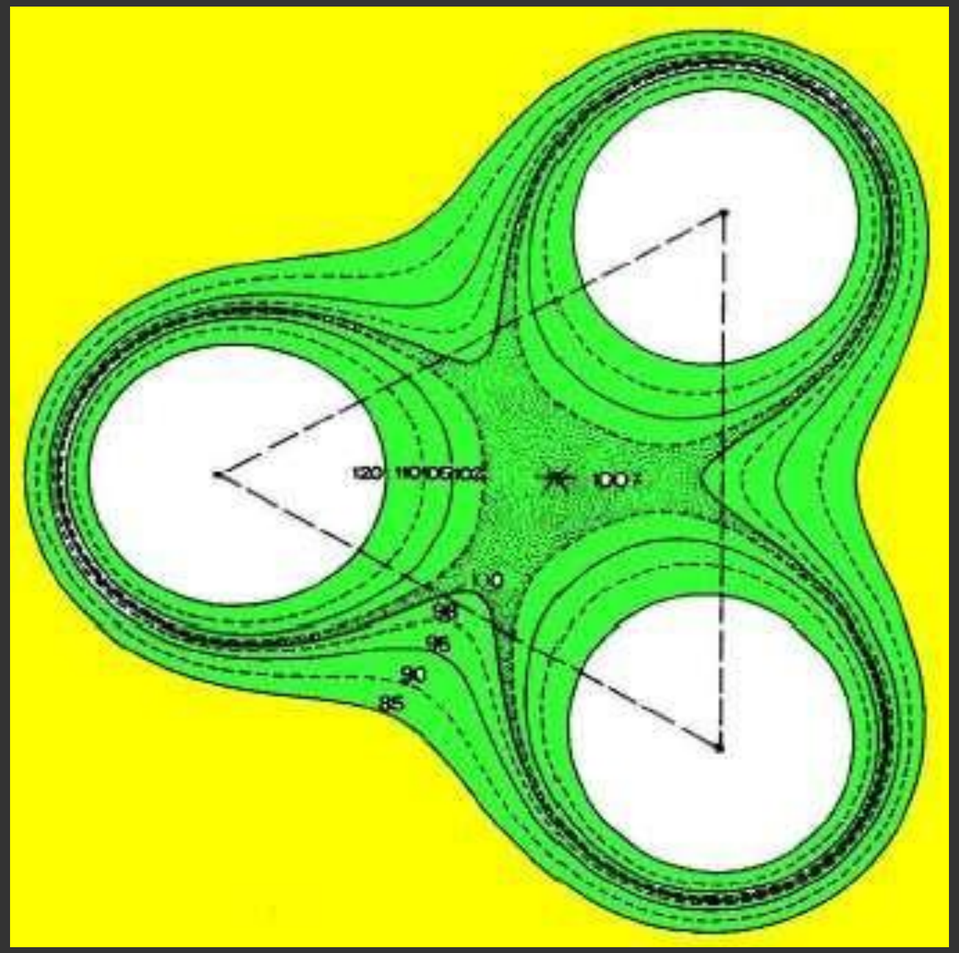


Central Planes in a complex implant



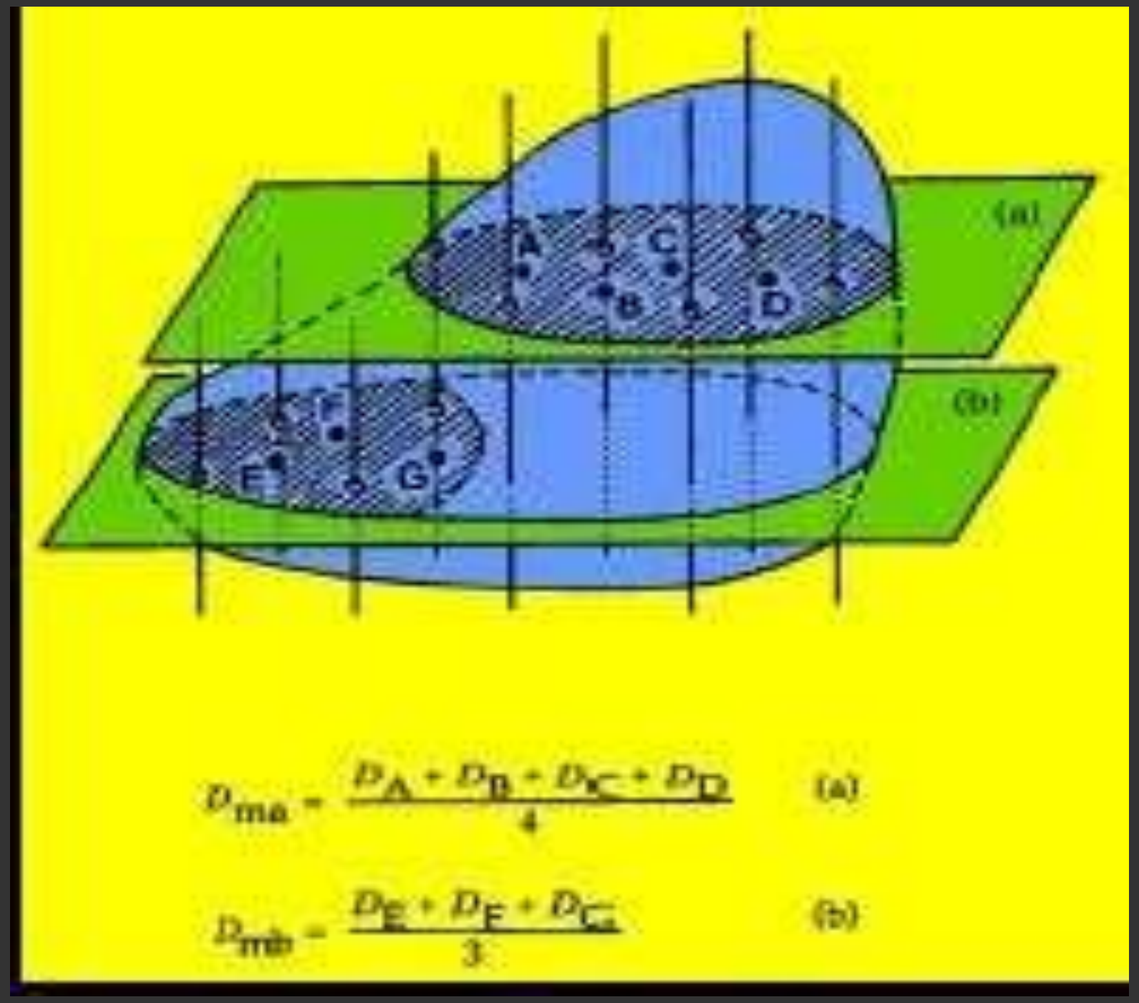
Prescription Dose Mean Central Dose (MCD) Multi plane : Dm

The minimum dose lies at the intersection of perpendicular bisectors of the sides of the triangles [geometric center] formed by these source lines.
This point is equidistant from all three source lines



Prescription Dose Mean Central Dose (MCD) complex implants : Dm

In some complex implants, a single central plane may not bisect or even include all the sources. In these cases, a mean central dose based on one plane can be misleading and it is advisable to subdivide the volume and to choose a separate central plane for each subvolume



Prescription Dose (continue)

High Dose Volume

The volume of tissue that is encompassed that will receive more than 150% of the mean central dose be reported.

The maximum dimension of the largest region in all planes calculated should be reported

Low Dose Volume

Defined as a volume within the clinical target volume, encompassed by an isodose corresponding to 90% of the prescribed dose.

The maximum dimension of the low dose volume in any plane calculated should be reported.

Prescription Dose (continue)

Dose Uniformity Parameters

ICRU defines the following two methods for the dose uniformity--

1.The spread of the individual minimum doses used to calculate the mean central dose in the central plane (expressed as a percentage of the mean central dose).

2.The dose homogeneity index-- defined as the ratio of minimum target dose to the mean central dose.

Prescription Dose (continue)

Dose Uniformity Parameters

7 line sources, 10 cm long, 2 cm spacing,
90]lGy.h-1 at one meter.
The mean central dose is 70.9 cGy.h-1

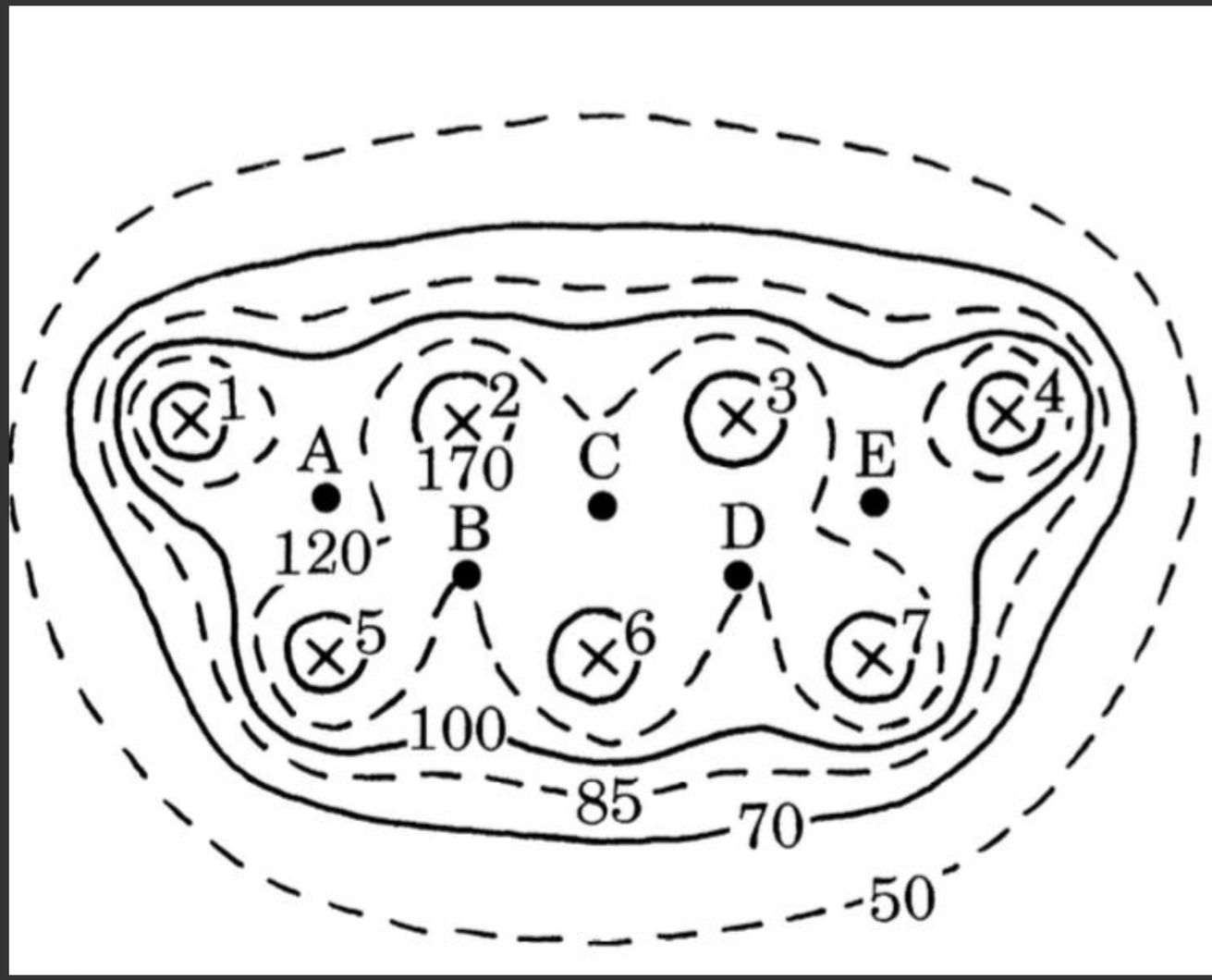
(the local minima in cGY.h-1 are *DA* = *DE* = *65.4*, *DB* = *DD* = 74.4 and *Dc* = 75.3).

The minimum target dose (100 %) is 58.1 cGy.h-1•

The spread in the individual minimum doses is from -8% to +6%.

The dose homogeneity index—
minimum target dose / mean central dose, is 0.82 = 58.1170.9.

Central plane of a two plane Breast Implant



Time Dose Factors

Time and Dose Rates for Temporary Implants

Time = Prescribed dose/initial dose rate

Time Dose Pattern for Temporary Implants

a. Continuous irradiation
b. Non-continuous irradiation
c. Pulsed irradiation

Recommendations for Recording and Reporting

Parameters Required for Recording and Reporting

. Description of Volumes : GTV, PTV,.....

. Description of Sources :

1. Radioisotope and filtration

2. Pattern of source distribution

- Description of Technique and Source pattern

Priority

Three levels of priority are recognized for reporting an interstitial therapy application.

They are linked to the different levels of dose computation sophistication needed to fulfill the reporting requirements (Visser, 1989)

Practical Applications of the Recommendations

Temporary Implants : Table 1.

Permanent Implant: Table 2

Single Stationary Source Line: Table 3

Moving Sources: Table 4

Surface Applicators : Table 5

Table 1: Levels of priority for reporting temporary interstitial implants

Parameters for reporting temporary interstitial implants	Priority[a]	Level[b] of computation
Description of Volume (3.A.i):		
Gross Tumor Volume	1	1
Clinical Target Volume	1	1
Treated Volume (2.6.4)	1	3
Description of Source and Technique (3.A.ii, 3.A.iii)	1	1
Radionuclide, type of sourc		
Source size and shape, source pattern		
Reference air Kerma rate		
Inactivity vector (applicator), if any		
Description of Time Pattern (3.A.iv)	1	1
Total Reference Air Kerma (3.A.v)	1	1

Table 1: Levels of priority for reporting temporary interstitial implants

Parameters for reporting temporary interstitial implants	Priority[a]	Level[b] of computation
Description of Dose (3.A.vi):		
a. Prescribed dose including point or surface of prescription[c].	1	1
Reference Dose in Central Plane		
a. Mean Central Dose	1	2
b. Minimum Target Dos	1	2
Description of High and Low Dose volume (2.F.vi,2.F.vii)	2	3
Uniformity Parameters (2.6.8)	3	3
Alternative Representation of Dose Distribution (2.F.ix)	3	3
Dose Rates at point or surface of prescription (2.G.ii, 2.G.iii)	3	3

a. Priority

1 . Concerned with doses in the central plan

2. Required calculations outside the central plan. If this is not available, then a more detailed description of source pattern under priority 1 is required.

3 . Additional information mostly of clinical research interest

b. Level of computation

1. No computer needed

2. Hand calculation and/or computer calculation in central plane.

3. 3-D computation needed

c. Essential to establish consistent reporting and related to past experience, necessary for comparison of brachytherapy data and for relating outcome to treatment.

Table 2: Levels of priority for reporting permanent interstitial implants

Parameters for reporting permanent interstitial implants	Priority[a]	Level[b] of computation
Description of Volume (3.A.i):		
Gross Tumor Volume	1	1
Clinical Target Volume	1	1
Treated Volume (2.6.4)	1	3
Description of Source and Technique (3.A.ii, 3.A.iii)	1	1
Radionuclide, type of source		
Source size and shape, source pattern		
Reference air Kerma rate		
Inactivity vector (applicator), if any		
Total Reference Air Kerma[c] (3.A.v)	1	1
Description of Dose (3.A.vi):		
Prescribed dose including method of prescription.	1	1
Reference Dose in Central Plane		
a. Mean Central Dose	1	2
b. Minimum Target Dose	1	2
Description of High and Low Dose volume (2.F.vi,2.F.vii)	2	3
Uniformity Parameters (2.F.viii)	3	3
Alternative Representation of Dose Distribution (2.F.ix)	3	3

Table 3: Levels of priority for reporting implants with a single stationary source line.

Parameters for reporting implants with a single stationary source line	Priority[a]	Level[b] of computation
Description of Volume (3.B.1):		
Gross Tumor Volume	1	1
Clinical Target Volume	1	1
Treated Volume	1	3
Description of Source and Technique (3.A.ii, 3.A.iii) RadioNuclide Length and Shape (Straight/Curved) Reference air Kerma rate Strength distribution (uniform linear strength is assumed, if not, distribution must be specified.) Diameter of inactive vector (applicator)	1	1
Description of Time Pattern (3.A.iv)	1	1
Total Reference Air Kerma (3.A.v)	1	1
Description of Dose and Prescription point (Distance from the source line position along the source line)	1	1
Minimum target dose if different from prescribed dose	1	1
Dose at 1 cm from axis of the source line at its center	1	1
Dose at the surface of applicator in contact with tissue	3	3
Additional representation of dose distribution (2.F.ix)	3	3
Dose Rate: Average overall treated dose rate at the point or surface of dose prescription (2.G.II, 2.G.III)	3	1

Table 4: Levels of priority for reporting implants with a moving source.

Parameters for reporting temporary interstitial implants	Priority[a]	Level[b] of computation
Description of Volume (3.A.i):		
Gross Tumor Volume	1	1
Clinical Target Volume	1	1
Treated Volume (2.F.iv)	1	3
Description of Source and Technique (3.A.ii, 3.A.iii)	1	1
Radionuclide, source type and source		
Type of movement		
Range of motion (effective length of source)		
Applicator-including diameter of inactive vector.		
Number of inactive vectors		
Reference air kerma rate		
Description of Time Pattern (2.G.iii)	1	1
Intervals between fractions		
Irradiation time per fraction		
Total Reference Air Kerma (3.A.v)	1	1
Description of Dose (3.A.vi): Prescribed dose	1	1
Minimum target dose	1	2
For single source line or bifurcation, dose at 1 cm	1	2
For complex implant, mean central dose	1	2
Method of dose optimization, if applicable	2	3
Description of high and low dose volume (2.F.vi, 2.F.vii)	2	2
Uniformity Parameters Additional representation of dose distribution (2.F.ix)	3	3
Alternative Representation of Dose Distribution (2.F.ix)	3	3
Dose Rates at point or surface of prescription (2.G.ii, 2.G.iii)	3	3

Table 5: Levels of priority for reporting implants with a surface applicators

Parameters for reporting use of surface applicators	Priority[a]	Level[b] of computation
Description of Clinical Target Volume (3.A.i):	1	1
Treated Volume (2.F.iv)	1	3
Description of Applicator (3.A.iii)	1	1
Shape (flat/curved, round/square, etc.)		
Size		
Description of source (3.A.ii)	1	1
Radionuclide and chemical form		
Concentration (seeds/tubes/plated)[c]		
Description of Time Pattern (2.G.iii)	1	1
Intervals between fractions		
Irradiation time per fraction		
Total Reference Air Kerma (3.A.v)	1	1
Description of Dose (3.A.vi):		
Prescription Dose and point of dose prescription	1	1
Dose at 5 mm in tissue at the center of the applicator[d]	1	2
Minimum target dose[e]	1	2
Description of high dose at tissue surface in contact with applicator, usually near the –center of the applicator.	2	2
Uniformity Parameters		
Additional representation of dose distribution (2.F.ix)	3	3
Dose Rates:		
Average dose rate at the point of dose prescription (2.G.II)	3	3

Selected references

1. ICRU Report 38: Dose and Volume Specification for Reporting Intracavitary Gynecology (1985)
2. ICRU Report 58: Dose and Volume Specification for Reporting Interstitial Therapy (1997)
3. The GEC ESTRO Handbook of Brachytherapy, Editors: Alain Gerbaulet, Richard Pötter, Jean-Jacques Mazeron, Erik van Limbergen (2002;107;3225-332
4. ESMP 2013 Reporting in Brachytherapy,Lecture 5 Brachytherapy Implantation.s


Thank You