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CONCEPTS OF BRACHYTHERAPY FROM BASICS TO BED SIDE PROSEDURE AN RADIATION ONCOLOGIST PROSPECTIVE

Radiotherapy

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ABSTRACT

There are two forms of brachytherapy

- Intracavitary radioactive sources are placed in body cavities in close proximity to tumor.
- Interstitial brachytherapy using radioactive seeds implanted directly in to the tumor volume

Bell -1903 first suggested implanting the radioactive source directly into tumor. Forshell -1931 coined term BRACHYTHERAPY Initially Radium was used as brachytherapy source. Nowadays Radium is not used because By product of radium is radio toxic. Radon gas emission is always a threat. Contamination can cause great problem.

Low specific activity of radium therefore require large source size, High Cost Disposal problem Above problem with Radium as a brachytherapy source leads to discovery of many other Radioactive isotopes .

KEYWORDS

Brachytherapy , Radium .

Discussion –

IDEAL BRACHY THERAPY SOURCE –

1- Should be γ emitter with energy 200 Kev
2- Preferably mono energetic.
3- Large T1/2 half life - temporary implant
4- Short T1/2half life - permanent implant.
5- No gaseous by product.
6- High specific activity
7- Insoluble & chemically non toxic.
8- Should be molded in various size & shape
9- Low cost.

Brachytherapy source is available in various physical forms such as Needle, tube pellets, seeds wire which facilitates their application in the patient.

FORMS OF APPLICATIONS-

I) Intracavitary
II) Interstitial
III) Intraluminal
IV) Surface Moulds.

ISOTOPE	HALF LIFE	AV. PHOTON ENERGY(MEV)	EXP. RATE CONSTANT (R cm2/mci-R)
Ra 226	1622 yrs	0.832	8.25
Co 60	5.26 yrs	1.25(Av)	13.07
Cs 137	30yrs	0.662	3.226
Ir 192	74.2 dys	.38(Av)	4.62
Au 198	2.7dys	0.412	2.327
I 125	60dys	.028 (Av)	1.208
Pd 105	17 dys	.21(Av)	
Samarium145	340 dys	.41(Av)	

SOURCES-

1-Co - 60 → Source available needle, tube, pellets for HDR after loading.
2-Cs - 137 → Needle, Tube, Beads for after loading.
3-Ir - 192 → as wire, pins for manual after loading. as pellets for remote after loading
4- I - 125 → Seeds for permanent implant For surface applicator

CS – 137-

- Largely replaced Radium as Nuclide of choice.
- Alkaline material, compound of cesium chloride/Sulphate is chemically stable.
- Recommended working half life is 10 years.

**All sources have recommended working life beyond which manufacture will not guarantee the Integrity of sources

- CS is available in needle form or tube or small pellet for Remote after loading machine.

Ir192 -

- Currently widely use
- high specific activity
- Flexibility - acquire the shape of tumor.
- Available in 0.8 mm dia. ,4.5 mm length

Au198/I125

Can be used for permanent Implantation
short half like.
Surface/mold application.
Now replaced by electron treatment of linac.

Co - 60-High specific activity & specific (Ralastron) γ-ray constant Make it attractive use for HDR.

Au198- Available in grains/seeds/wires.

- With the help of Implantation Guns directly fit in tumor area.
- **Use** as permanent implantation purpose also in malignant plural effusion and malignant ascitis.

I 125- available in seeds form, as permanent Implant or plaque. Directly applied in tumor area as in case of treatment of Single solitary retinoblastoma.

PRACTICAL ASPECTS IN BRACHY THERAPY-

- Activity of a source is the apparent activity because real activity of source is attenuated because of source encapsulation thus true activity is always greater than this activity.
- **Exposure rate constant** (γ-Rays constant of Source) is defined as dose rate CGY/Hr at a distance of 1cm from milicuri activity of point source; this is however redefined because of source encapsulation (attenuation effect).

Point Source-

- From a single point source a γ - Ray is emitted isotropically. It follows Inverse square law therefore Intensity of radiation will decrease with square of the distance from the source.
- The Dose Rate will be proportional to activity of source as well as Inverse Square of the distance d from source.

MULTIPLE SOURCE-

- Five equally spaced line of the source.
- Each emits γ - Ray in all direction producing complex pattern of isodose distribution.
- It has been seen that point close to source in the same horizontal axis will receive high dose and point between the two source will receive low dose.

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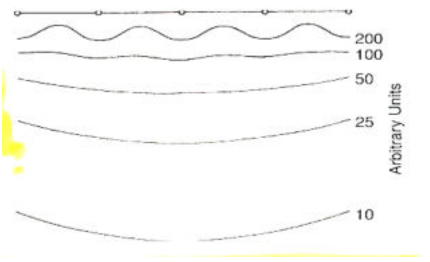

FIG -1 Inference drawn from above figure – are,

1- Uniformity of dose achieved depends on both distance from source and spacing between the sources.
2- Uniformity of the dose further improved by increasing the activity of source at the end of the line.

Methods of Application of Brachy Therapy-

1- Pre Loading Method.
2- Manual after loading.
3- Remote after loading.

A-Pre loading -Source are loaded in applicator before they are inserted into patient. Because of Radiation exposure to medical and paramedical staff leads invention of after loading method.
B-Manual after loading - first applicator are in pt. then sources are manually inserted into applicators.
C- Remote after loading - Each applicator is fixed in the pt. and check X-ray carried out to localize dummy source in applicator.

Source movement-

- Combination of various source train with option to choose.
- Small miniature source with spacer enabling the operator to create his on source configuration.
- By single source with option of different (dwell times) → (How much dose to be delivered at different site.) at various position simulating either as many point

Optimization of dose

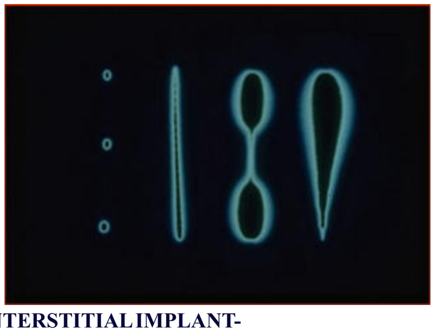

FIG-2 INTERSTITIAL IMPLANT-

- It is important to clearly define target volume and to have pre planned number and distribution of Radioactive sources to be used.
- Homogeneous dose distribution is very important because high dose around each source cab cause neurosis low dose between the source could result in recurrence

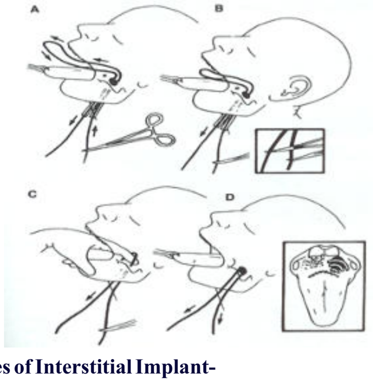

FIG -3 Rules of Interstitial Implant-

- Active source should be parallel and straight.
- Line should be equidistant.
- Line or plane on which the mid point of the source lies should be at right angle to axis of the source.
- Linear activity of the source should be uniform along the length of each line.
- Separation between sources may vary from one implant to other implant. But minimum 8 mm separation is acceptable for smallest volume rising to 20 mm largest.
- Average length of active wire should be larger than target volume by 25-30%.

TYPES OF IMPLANT-

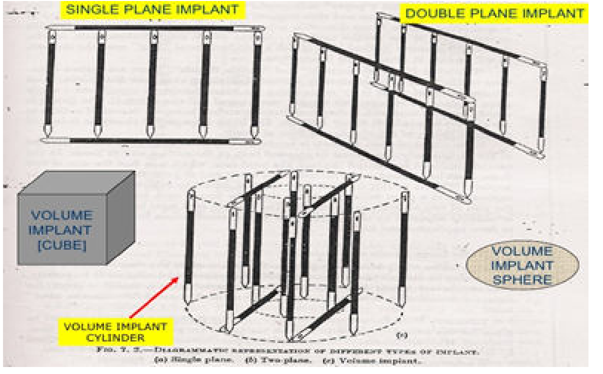

FIG -4A

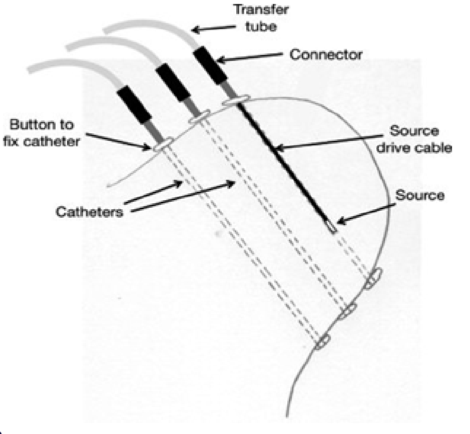

FIG-4B

Figures-4 A and 4B- SINGLE PLANE IMPLANT/ LOOP TECHNIQUE.

CLINICAL SITUATIONS-

If you get a patient who had been operated for T2 lesion developed neck node as recurrence and neck node showing extra capsular spread as shown on MRI neck then only neck node dissection and external beam radiotherapy gives you poor result almost 50% recurrence, but if you go with interstitial brachytherapy after neck node dissection failure rate is decrease up to 20% only.

Interstitial Bracytherapy In Soft Tissue Sarcoma-

Flexible wire implant to be used, we can use horizontal implant or vertical implant but in horizontal implant you require less number of catheters after putting implant you require to measure distance between catheter it should not be less than 1 cm and should not be more than 1.5 cm , in low grade soft tissue sarcoma brachytherapy used if its size is more than 5cm or it's a recurrence case dose given 36Gy in 9 fractions as HDR brachytherapy .

During implant , catheter care must be given to protect neurovascular bundle in tumor bed we use jelfoam spacer to maintain adequate distance between catheter and neurovascular bundle .

Paris system of dose calculation-

Based on the distribution of sources in the central plane – that is, the plane which is at right angles to the axis of the mid-point of the sources.

- The basal dose rate represents the dose in the centre of the implanted volume, and is defined as the dose rate at a point in the

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middle of a pair or group of sources where the dose rate is lowest. In the case of a large implant, there may be several pairs of groups of sources arranged in triangle or squares. For these, a mean basal dose rate is taken for the implant as a whole.

- The basal dose rate a point is the summation of dose contributions from each source obtained from graphs of dose rate variations with distance from the source
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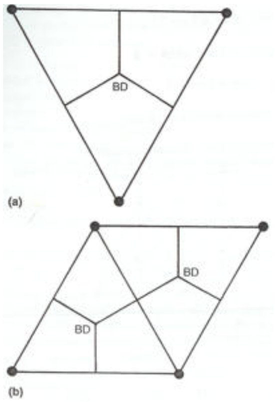


FIG-5 A and 5B

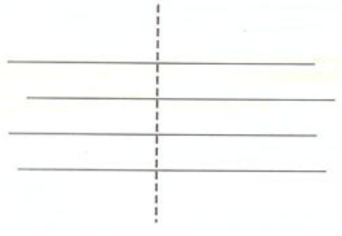
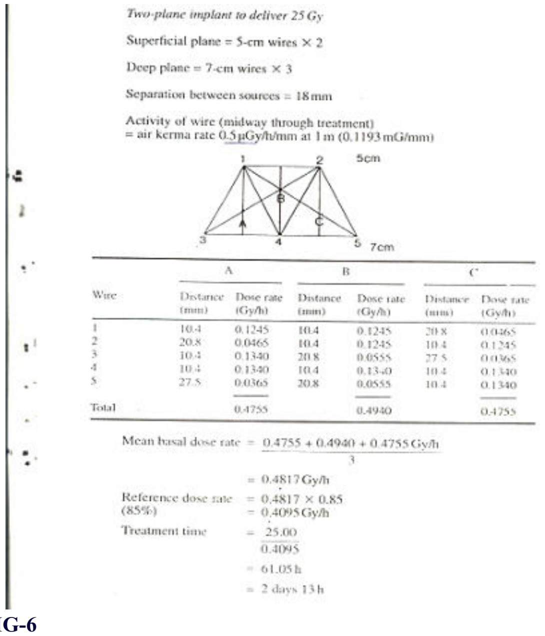


FIG-5C

- Once the basal dose rate in the centre of the implant has been defined, the reference dose rate is taken as 85% of the BDR. This serves to calculate the duration of the implant, and the 85 % isodose defines the treated volume.
- A value of 85 % has been chosen to provide an isodose contour that reasonably covers the target volume with an acceptable variation between the dose at the centre and that at the periphery of the target volume. The time for which at implant must be left in place is derived by dividing the prescribed dose by the reference dose rate.



Two-plane implant to deliver 25 Gy

Superficial plane = 5-cm wires × 2

Deep plane = 7-cm wires × 3

Separation between sources = 18 mm

Activity of wire (midway through treatment)
= air kerma rate 0.5 μGy/h/mm at 1 m (0.1193 mG/mm)

Wire	A		B		C	
	Distance (mm)	Dose rate (Gy/h)	Distance (mm)	Dose rate (Gy/h)	Distance (mm)	Dose rate (Gy/h)
1	10.4	0.1245	10.4	0.1245	20.8	0.0465
2	20.8	0.0465	10.4	0.1245	10.4	0.1245
3	10.4	0.1340	20.8	0.0555	27.5	0.0365
4	10.4	0.1340	10.4	0.1340	10.4	0.1340
5	27.5	0.0365	20.8	0.0555	10.4	0.1340
Total		0.4755		0.4940		0.4755

Mean basal dose rate $= \frac{0.4755 + 0.4940 + 0.4755\ \text{Gy/h}}{3}$

$= 0.4817$ Gy/h

Reference dose rate (85%) $= 0.4817 \times 0.85$
$= 0.4095$ Gy/h

Treatment time $= \frac{25.00}{0.4095}$

$= 61.05$ h

$=$ 2 days 13 h

FIG-6

Rationale of LDR Brachytherapy-

It has been known for many decades that lowering the dose rate generally reduces radiobiologic damage. The explanation of this effect, relating to sub lethal damage repair, also has been long understood.

Increasing the dose rate will increase late effects much more than it will increase tumor control. Conversely, decreasing the dose rate will decrease late effects much more than it will decrease tumor control. Thus the "therapeutic ratio" (ratio of tumor control to complications) increase as the dose rate decreases.

Rationale for LDR brachytherapy - LQ model—

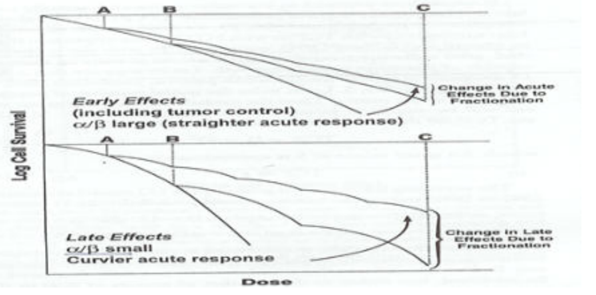


FIG -7

- These observations can be interpreted in terms of the / ratio. In terms of survival curves, the / ratio essentially describes the degree of "curviness" of the acute survival curve.
- A small value of / means that the (dose squared) term is dominating at radiotherapeutic doses, resulting in a curvy survival curve.
- A large value of / means the terms is dominating, resulting in a straighter survival curve.
- Now, as a first approximation, the dose-response relation for a fractionated (or LDR) regimen can be thought of as simply the results of multiple repeats of the initial part of the survival curve.

DOST RATE & ICRU-38 RECOMMENDATIONS- ICRU 38 defines-

- LDR - .4 to 2 Gy/Hr
- MDR 2 to 12 Gy/Hr
- HDR > 12 Gy/Hr
- Most of the LDR & MDR - CS-137 as a source HDR - Ir192 , Co-60 as source.

ICRU-38 recommendations for CA Cervix—

- Treatment technique must be described
- Reference volume should be described in terms of height, width & thickness of the volume enclosed in 60 Gy Isodose for LDR treatment in CA cervix.
- Absorbed dose at bladder reference/Rectal reference/lymphatic trapezoid reference point and pt. A and pt, B as well dose determined on computer to avoid extra dose to the above said area.

Pulse dose Brachytherapy

A-PDR was proposed to exploit the advantage of HDR as well as LDR.
B-It was seen varying dwell time of the stepping source dose optimization could be achieved which maintain the potential benefit of LDR.

Why PDR?—

In effort to replace the continuous LDR T/T lasting several days patient is hooked up for several days, where as in PDR source of pulse 10min/Hr delivered. It offers practical advantage that patient's nursing care can be done more frequently which was not possible in LDR treatment where patient. Was hooked up continually for 72 hr.

DO AND DONTS IN BRACHYTHERAPY –

Following points must to keep in mind

- Brachytherapy planning requires military discipline.
- Radiation oncologist must be fully aware of each and every applicators its dimension and its lengths .
- Tip of catheter and Dwell point distance must be known , distance travel by source from catheter tip to first dwell point is called as **Indexer Length .**

- After implant procedure done get and CECT done ideal to acquire image.
- On CT images we do target volume delineation.

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