Principles of Intracavitary Brachytherapy

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Importance of ICA in Ca Cervix

Most common cancer

Radiotherapy → Definitive Treatment

Brachytherapy an integral part

High doses to tumor with sparing of normal tissues

Independent prognostic factor

Nori D, Dasari N, Allbright RM, *et al*. *Semin Radiat Oncol* 2002;12:40-52.
Lanciano R. *Semin Radiat Oncol* 2000;10:36-43.

Accurate applicator placement not only related to Local control and Survival but also normal tissue toxicities

Corn BW, Hanlon AL, Pajak TF, *et al*. *Gynecol Oncol* 1994;53:294-300.
Lanciano RM, Won M, Coia LR, *et al*. *Int J Radiat Oncol Biol Phys* 1991;20:667–76.
Katz A, Eifel PJ. I*nt J Radiat Oncol Biol Phys* 2000;48:1417-1425.

Evolving concepts in Brachytherapy

- **1898** — Marie and Pierre Curie discovery of *Radium*
- **1903** — Margaret A. Cleaves describes the treatment of a gynecological patient with intracavitary radium.
- **1904** — W. Pusey and E. Caldwell treat uterine cancer with a radium capsule inserted in the uterus. First report of intracavitary treatment.
- **1905** — L. Wickman and P. Degrais designed applicator for intracavitary therapy
- **1914** — **MUNICH SYSTEM**
- **1910-1920** — **PARIS SYSTEM**
- **1913-1914** — **STOCKHOLM SYSTEM**
- **1938** — **MANCHESTER SYSTEM**
- **1963** — Afterloading technique is described.
- **1974** — **HDR** Brachytherapy is introduced.
- **1985** — **ICRU 38**
- **1980s** — **ImageBased (CT/USG)**
- **2000** — **MRI Based Planning**
- **2005** — **GEC ESTRO** recommendations for **ICBT**

History of Intracavitary Brachytherapy

- For the first 50 years or so of Ca Cervix brachytherapy, applicators were first loaded with radium (or later cesium)sources and then inserted 'live' into the patient.

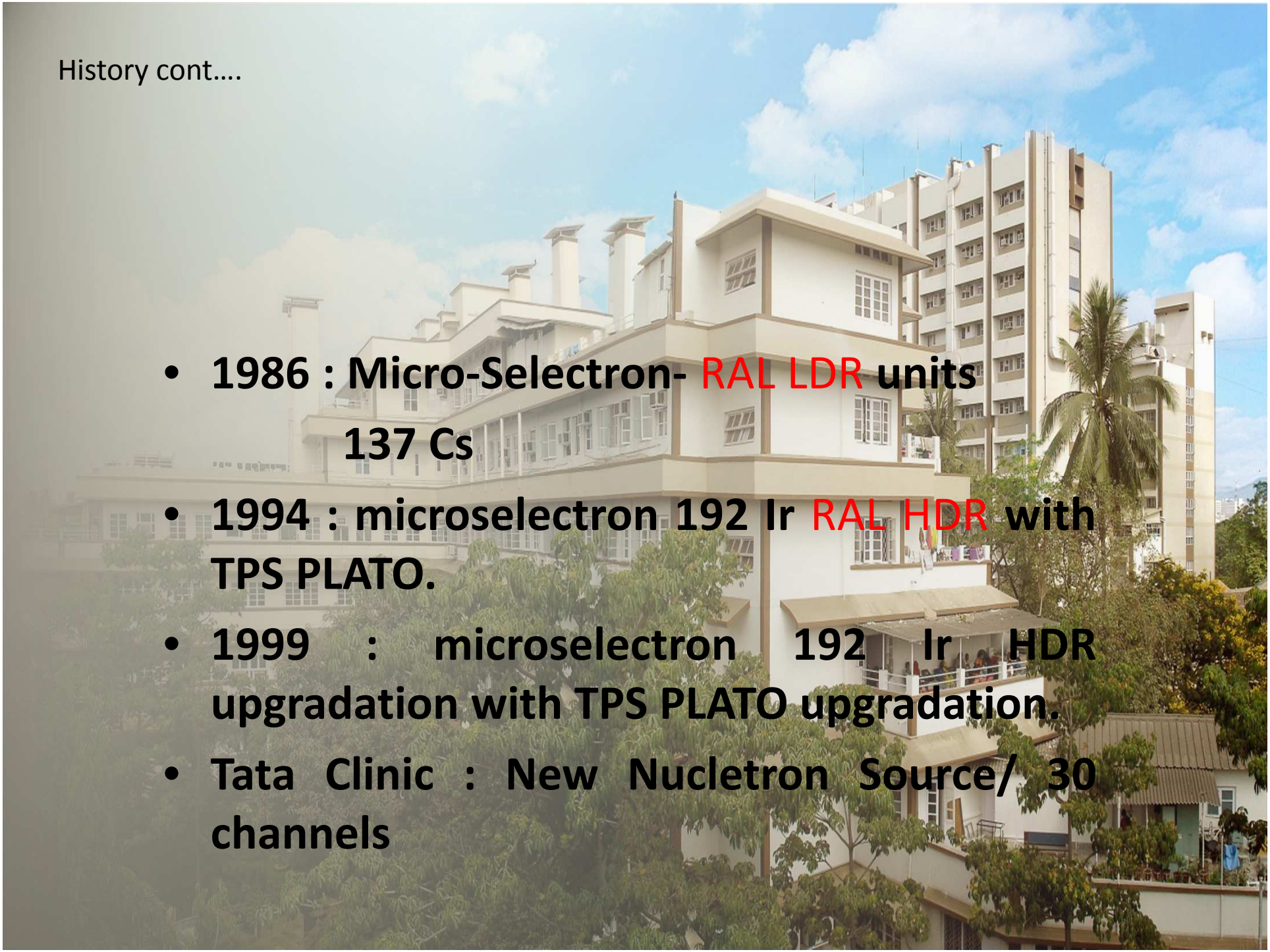
- Break through in Cervix brachytherapy came in the early 1960s with the advent of 'afterloading', whereby applicators were inserted into the patient 'cold' and then loaded with the radioactive sources at a later time.

- The introduction of remote afterloading (RAL) , the exposures were reduced. This occurred in the mid-1960s .

History of brachytherapy in carcinoma cervix : TMH

- **Till 1948: RADON seeds.**
- **Till 1960 : Manchester applicator**
  (Dunlop Rubber Company, Manchester).
- **1960: Preloaded 60Co and 137Cs capsules**
- **1972 :Manual afterloading technique with 60Co.**
- **1976 : Cs^{137} tubes from BARC (after loading).**
- **1979 :Cs^{137} tubes from Amersham (after loading).**

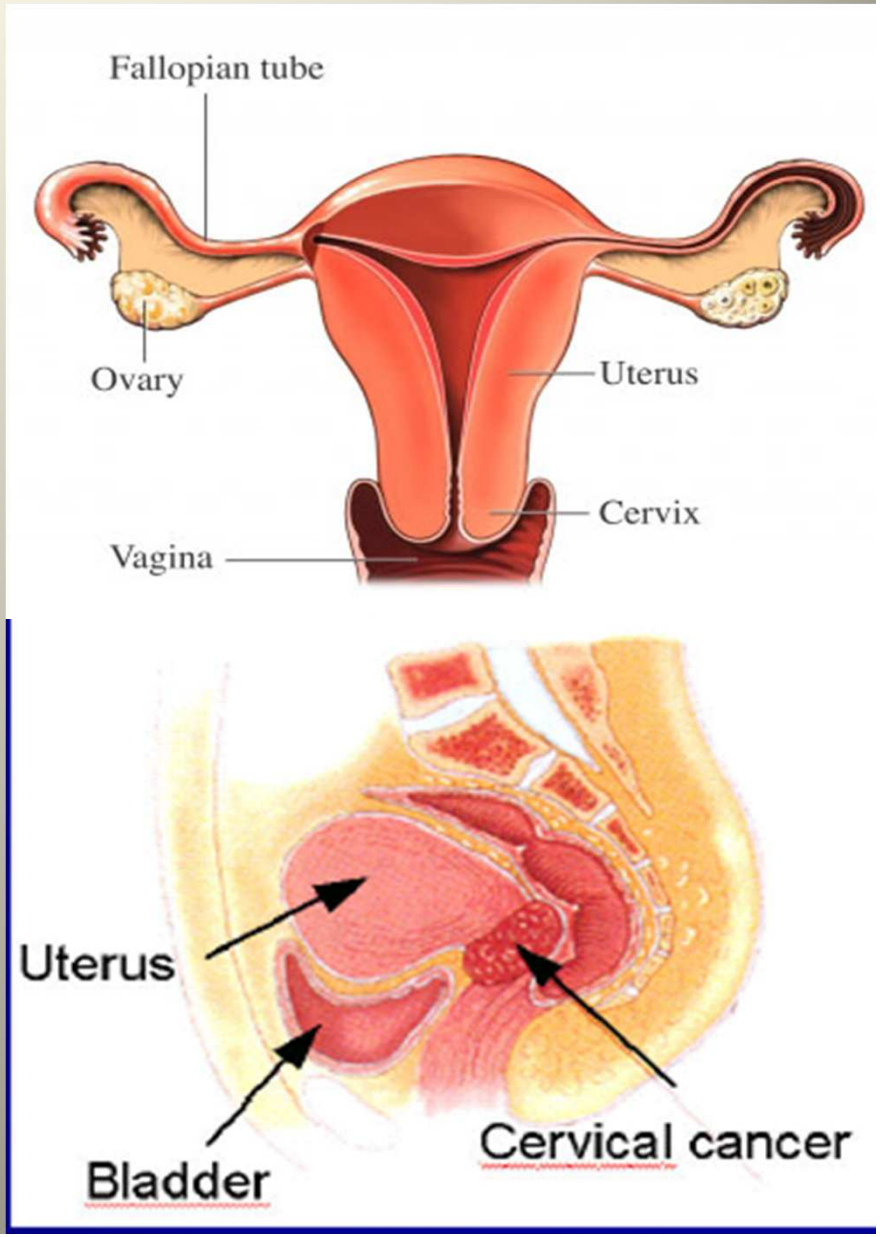
History cont….



- **1986 : Micro-Selectron- RAL LDR units**
  137 Cs
- **1994 : microselectron 192 Ir RAL HDR with TPS PLATO.**
- **1999 : microselectron 192 Ir HDR upgradation with TPS PLATO upgradation.**
- **Tata Clinic : New Nucletron Source/ 30 channels**

Why ICA works in Ca Cervix

- Anatomy
- Radiation source in /around tumor
- Away from normal tissues susceptible to late radiation damage
- Packing, retraction , optimal source distribution, applicator shielding- can be applied to keep normal tissues dose below dose received by tumor.
- Hence ,normal tissue susceptible to late radiation damage receive much less dose than tumor



DOSIMETERIC SYSTEM

- Any dosimetric system is a set of rules for arrangement of a specific set of radio isotopes in a specialised applicator to deliver a designated dose to a designated points.
- A system specifies the following:

1. Type of radioisotope to be used.
2. The geometrical arrangement of radioisotope.
3. Specification of the treatment in terms of the dose, time and fractionation.

Munich System,Germany

- Initially proposed in 1912 by Carl Joseph
- The “Pin and plate” method.
- Radium sources in the intrauterine tube
- In the cervical plate groves were made to accommodate a number of small radium sources.
- Two insertions each of 24 hours separated by 2 weeks were given.

Stockholm System

- **Forsell and Heymen (1914)**- predecessor of modern day brachy
- Radiumhemment,Stockholm, Sweden
- NON- FIXED APPLICATOR **Applicators not fixed to each other**
- Fractionated brachytherapy concept
- **Used preloaded uterine rubber tube(53-88 mg Radium) and vaginal silver/gold box (60-80 mg Radium).-*UNEQUAL LOADING***
- **2-3 insertions, 3 weeks apart.**
- **Each of duration around 20-30 hr.**
- **Total mg-hrs were usually 6500-7100, out of which 4500 mg-hrs was in vagina.**

Figure 7. Manchester technique vaginal ovoids and Stockholm technique boxes.

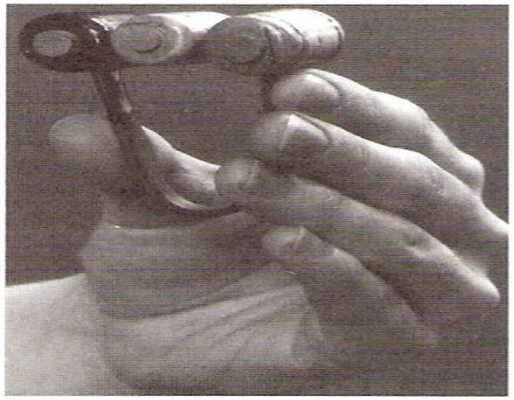
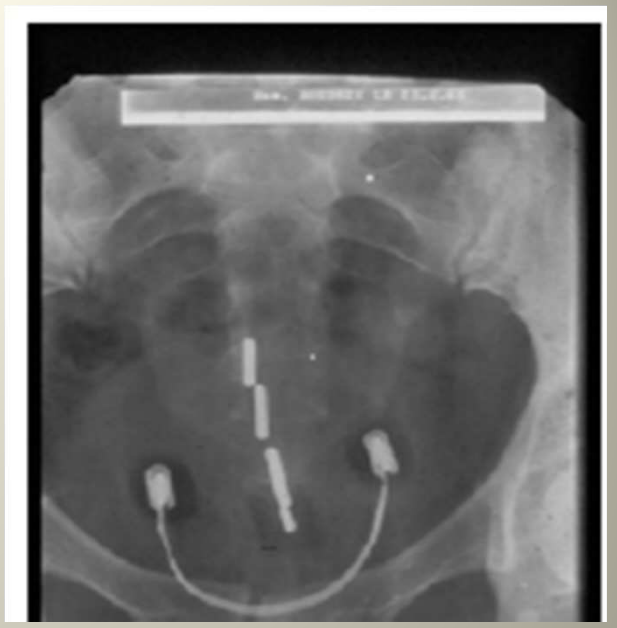


Figure 6. Paris technique cork applicators.

Paris system



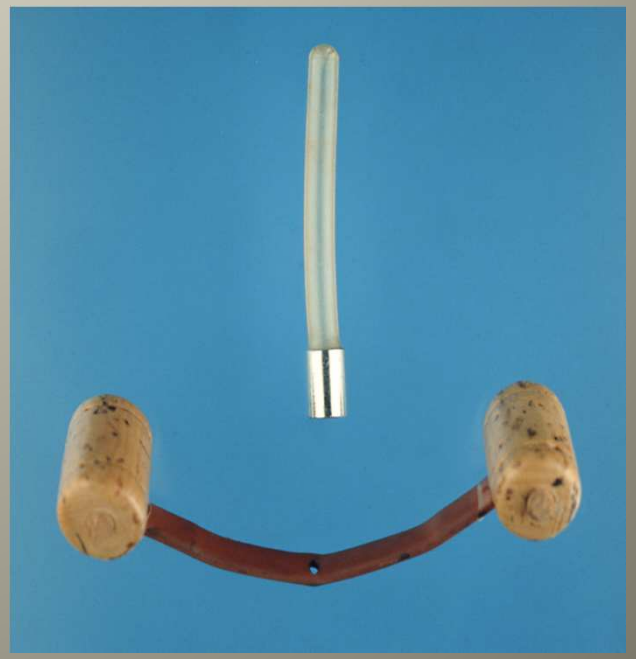
- **Regaud (1926).**
- **Cork applicator**

Preloaded uterine tube(33.3mg Radium)in ratio of 1:1:0.5

two vaginal corks(13.3mg Radium in each)

EQUAL LOADING PATTERN

- Single application. (UNFRACTIONATED)
- Continuous 5 days to deliver 7200-8000 mg-hrs.



Concept & issues with mg -hrs

- Pre-computer;
- radium era-prescription

  = total mg of radium X duration in hours

  e.g- 5 radium sources each of 10 mg kept for 48 hrs=5X10X48=2400 mg hrs

DRAWBACKS-

1. No info about dose distribution around the applicator
2. Works only with tandem and ovoid in particular geometry.
3. Dose prescription in terms of mg-hr ignored **anatomical targets and organs at risk**.
4. For EBRT ,absorbed dose; concept of mg hrs for brachy!

MANCHESTER SYSTEM

Developed by Todd & Meredith in 1930 and pioneered by Patterson & Parker.

- Revised TOD MERIDITH ,British Journal Radio 1953.

POINT BASED PRESCRIPTION SYSTEM

Todd & Meredith (Holt Radium Institute, Manchester, England)

1. **Recognized that unique dosage system was necessary for pelvis.**
2. **Abandoned previous dosage system of mg./hrs. in favour of roentgen unit.**
3. **Defined the treatment in terms of dose to a point.**
4. **Stressed the importance of constant dose rate.**
5. **Introduced reproducible technique which could aim at better tumour control and less radiation morbidity.**

MANCHESTER SYSTEM

Defined two points – A & B

Point A

- **anatomically comparable from patient to patient**
- **where the dose is not highly sensitive to small alteration in applicator position**

- **Allows correlation of the dose levels with the clinical effects**

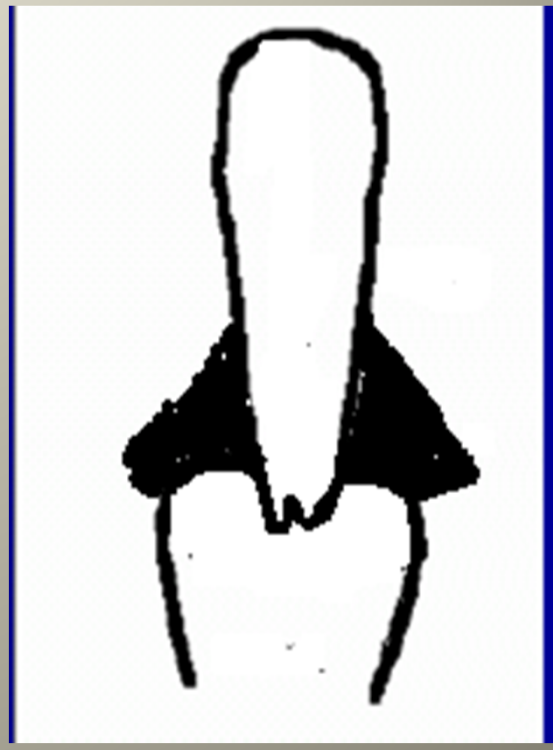
- **Designed a set of applicators and their loading which would give the same dose rate irrespective of the combination of applicators used**
- **Formulated a set of rules regarding the activity, relationship and positioning of the radium sources in the uterine tandem and the vaginal ovoids, for the desired dose rate .**

How point A came into existence?

- **Radiation necrosis –**due to high dose area in medial edge of broad ligament *where* ***uterine vessels cross the ureter, not bladder /rectum-TODD***

- pyramid shaped area **Paracervical Triangle** –minimal radiation tolerance

- Tolerance of this paracervical triangle is the main **limiting factor** in irradiation of uterine cervix.



POINT A

- Fixed point 2cm lateral to the center of uterine canal and 2 cm above from the mucosa of the lateral fornix

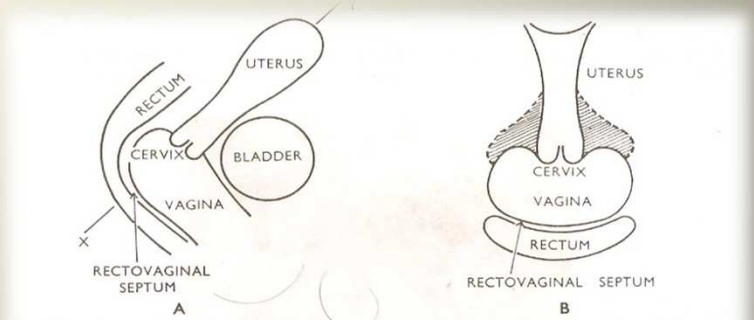


Fig. 434.—Anatomical relationships (diagrammatic) of the uterine cervix and neighbouring structures. A, Sagittal section. B, Plan in plane *XY* of A.

POINT B

- Same level as point A but 5 cm from midline
- Rate of dose fall-off laterally
- Proximity to important obturator LNs
- Dose ~15-20 % of the dose at point A

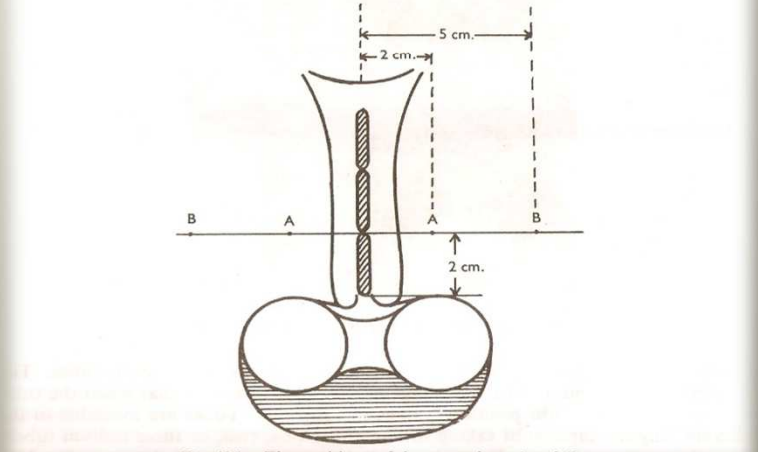
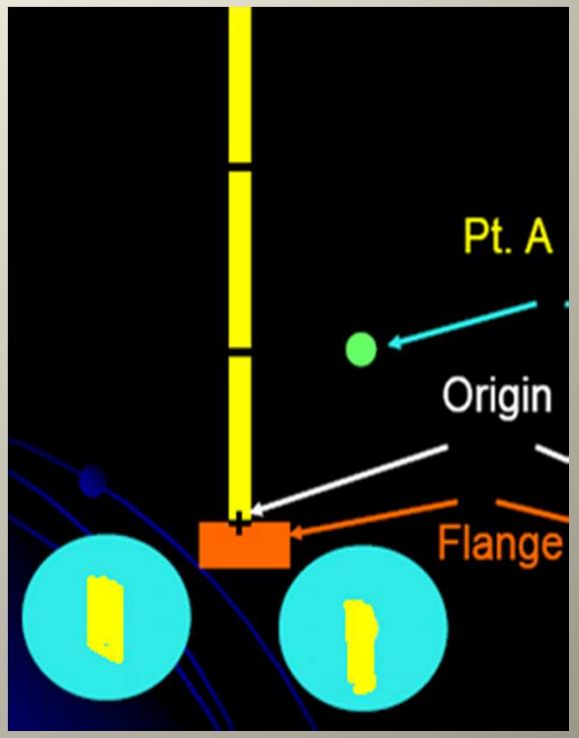


Fig. 435.—The positions of dosage points *A* and *B*.

Revision of point A

1953- 1st revision

2 cm superior from lower end of central radium tube and 2 cm lateral from uterine canal in radiograph of radium insertion.



2nd revision

2 cm above the external os and 2 cm lateral to the uterine axis .

3rd revision

2cm above and 2 cm lateral to the centre of the flange along the uterine tandem

Intra uterine tubes

- **Thin rubber or plastic tubes with flange at end and other end closed.**
- **DUNLOPRUBBER COMPANY,MANCHESTER**
- **Available in three lengths,2 cm, 4 cm and 6 cm, meant for one, two and three radium tubes respectively.**
- **Each radium tube was of 2cm length (active length =1.35cm)**

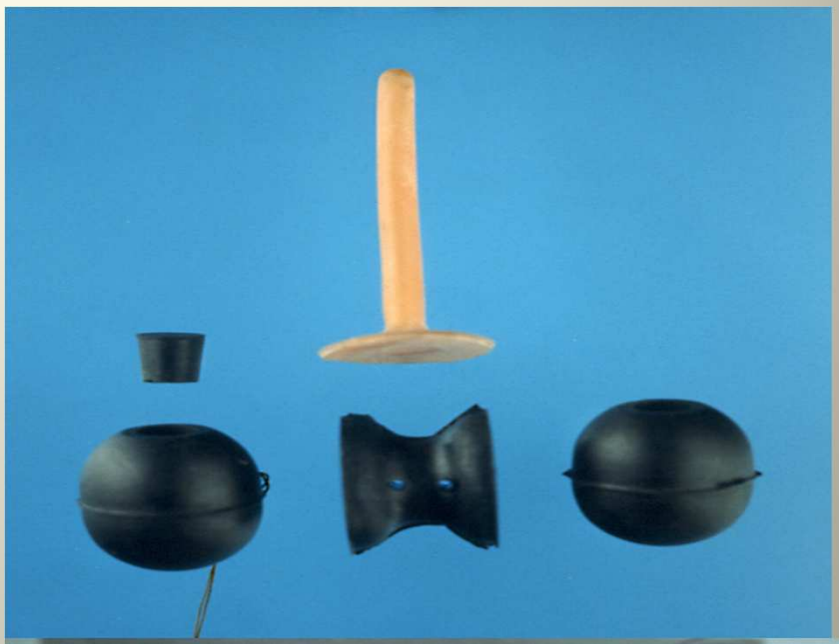
Vaginal ovoids

- Modification of corks of Paris system
- Made up of rubber /nylon
- Shape ‘Polaroid elliptoid’
- Bore in axis of revolution –loading 2cm Ra-active length 1.35 cm
- Ovoids-
- Large 3 cm
- Medium 2.5cm
- Short 2cm

‘Spacer’ (rubber) fixes distance between them at 1 cm

For vaginal size intermediate to that ‘washer’ was used

At least 1.5 cm of gauze packing was used behind ovoids to prevent their movement during treatment period and to hold away rectovaginal septum.



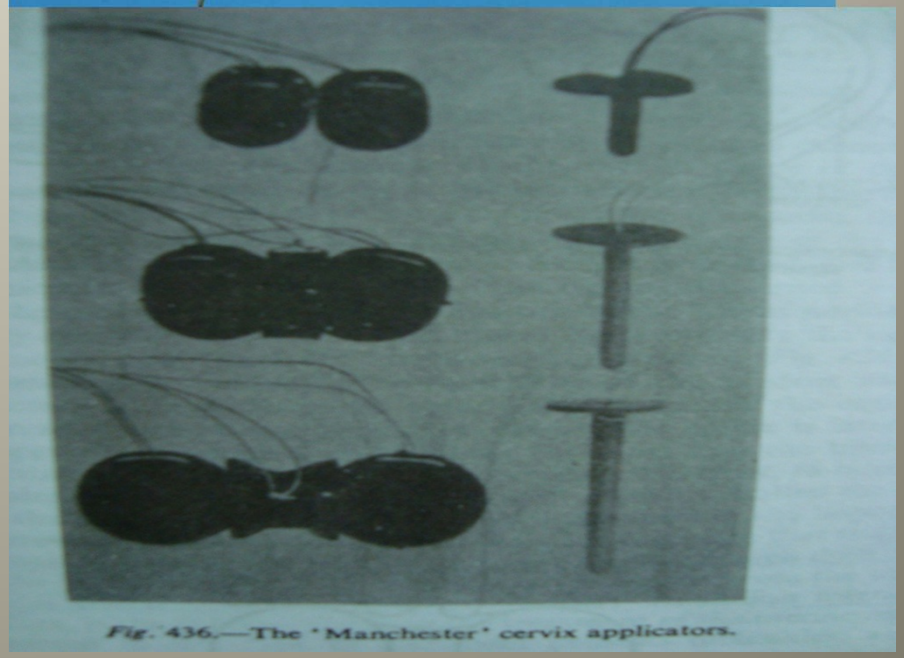
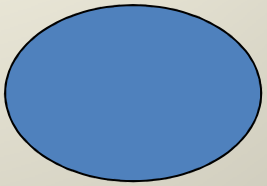


Fig. 436.—The 'Manchester' cervix applicators.

Radium sources and their loading

- **1 Unit of radium was defined as 2.5 mg of radium with 1 mm platinum filtration.**
- **All loadings in intrauterine tubes and vaginal ovoids were made integral multiples of this unit.**

Step 3 cont……

Intrauterine applicators 	Loading in terms of units Cx to fundus		Vaginal ovoids 	Loading in terms of units (In each)
Large 6 cm	4-4-6 (10-10-15 mg)		Large 3 cm	9 (22.5 mg
Medium 4 cm	4-6 (10-15 mg)		Medium 2.5 cm	8 (20 mg)
Short 2 cm	8 -10 (20mg)		Short 2 cm	7 (17.5 mg

Step 3 cont……

Dose specification

- Optimal total dose to point A: 8000R
  (4000 Rx2) (72.8Gy)
- 1-2 sessions
- Each of 72 hr duration
- ~ 1 week (4-7days) apart.
- Dose rate 55.5 R per hour.
- Not more than 1/3rd of total exposure rate at point A should be delivered from vaginal radium.

PROCEDURE OF IMPLANT

- Pre-op investigations and preparation of patient.
- Knee-chest position on operating table.
- IV anaesthesia.
- C & D.
- Sim's speculum inserted….posterior vaginal wall pulled up.
- Cx canal searched for & slightly dilated & uterine length measured.

Step 4 cont…….

- Estimate size of paired ovoids.
- Load uterine tube with correct no. of units & insert with flange at os.
- 1st ovoid ➡ L-shaped retractor ➡

  Spacer / washer ➡ 2nd ovoid.
- Ovoids rest on anterior vaginal wall.
- Posterior vaginal packing with radio-opaque gauze.
- Scintillation counter kept in rectum to measure exposure rate –if high then removal and replacement
- Whole application should end in 15 mins.

Permissible organ tolerance ,if exposure rates of 55.5R/hr over 10 days

- If dose at Point A : 8000 R.
- Uterus: 30000 R
- Vaginal mucosa : 20000-25000 R.
- Rectovaginal septum : ~ 6750 R

Probe with scintillation counter
Todd and Meredith

Exposure and absorbed dose

- Absorbed dose in rad =

  exposure in roentgen x f

f = 0.957, for soft tissue and radium gamma rays or for gamma rays from any other sources likely to be used.

Drawbacks of point A

- It relates to position of sources and not to specific anatomic structure.
- Depending on size of cervix

  point A may be inside or

  outside of tumor resulting in under /over dosing of anatomical cervix
- different centres have used different definitions of point A, which makes comparison of data between different centres difficult.

Manchester system : most acceptable brachytherapy technique

- concept of specification of dose to a single point.
- Source loading rules were defined in a way that point A receives same dose rate no matter which ovoid and intrauterine combination is used.
- In place of 226Ra, radium substitutes can be used with appropriate correction factors applied. Loose system and therefore, can suit to any anatomical situation.
- Well studied method and hence control rate and morbidity is well defined.
- It is cost effective.

Manchester System

Dis-advantages:

1. Loose system and therefore, chances of slipping of ovoids and hence disturbed geometry and creation of cold and hot spots leading to high failure or increased morbidity.
2. Radiation hazard : being a preloaded system.

This led to development of fixed preloaded and afterloading applicators.

Fletcher-Suit-Delclos applicator system

*Derived from Manchester system.

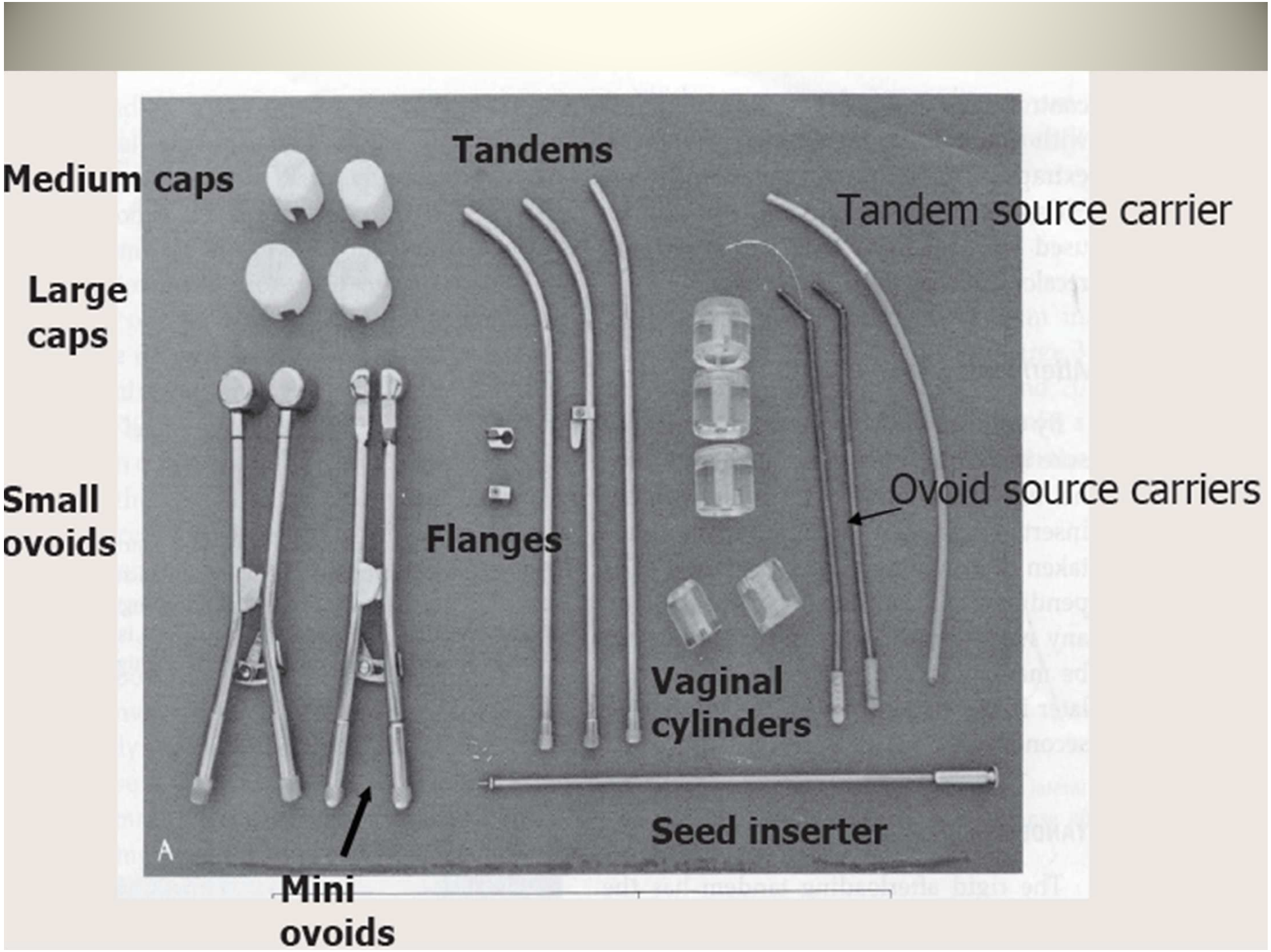
*Afterloading ability.

*Internal Shielding- shields are located on the medial aspects of the anterior and posterior colpostat faces

*Colpostat …. diameter of 2 cm that can be increased to 2.5 and 3 cm by use of small and large slip-on plastic caps,- 15, 20, and 25 mgRa EQ of CS137 for small, medium, and large colpostats

*Central tandem 8cm (15-10-10-10),6cm loading (15-10-10),2 cm (20) RaEq with 137cS.

Applicator shielding reduces bladder and rectum doses by 21 to 34%- decrease the requirement of 1.5 cm packing –rectovaginal septum


Medium caps
Large caps
Small ovoids
Tandems
Tandem source carrier
Ovoid source carriers
Flanges
Vaginal cylinders
Seed inserter
A
Mini ovoids

ICRU38

DOSE AND VOLUME SPECIFICATION FOR REPORTING INTRACAVITARY THERAPY IN GYNECOLOGY

Issued : 1 March 1985

Aim: to develop common system to report , communicate and compare intracavitary treatments given at different centres.

Dose Rates

- Low dose rate : 0.4 – 2 Gy / hr
- Medium dose rate : 2 – 12 Gy / hr
- High dose rate : >12 Gy / hr or
  >0.2Gy/min
  (commonly used 0.5 –5 Gy/min)

Treatment duration should always be reported.

Description of Reference Volume

i.e. *volume encompassed by reference isodose surface*

A Dose Level

- An absorbed dose level of 60 Gy is widely accepted as appropriate *reference level for classical LDR.*
- When more than one ICA are performed , absorbed dose is that resulting from all applications. Time –dose pattern should be clearly stated.
- When ICA combined with EBRT, ISODOSE LEVEL to be considered is *difference between 60Gy and dose delivered by EBRT.*e.g. 20 Gy EBRT , isodose level to be considered (60 – 20) = 40Gy.
- For MDR & HDR ,therapist has to indicate dose level which he *believes to be equivalent to 60 Gy* delivered at classical LDR.

Reference volume : Description of Pear-Shaped volume

Pear-shape….longest axis coincident with intrauterine source.

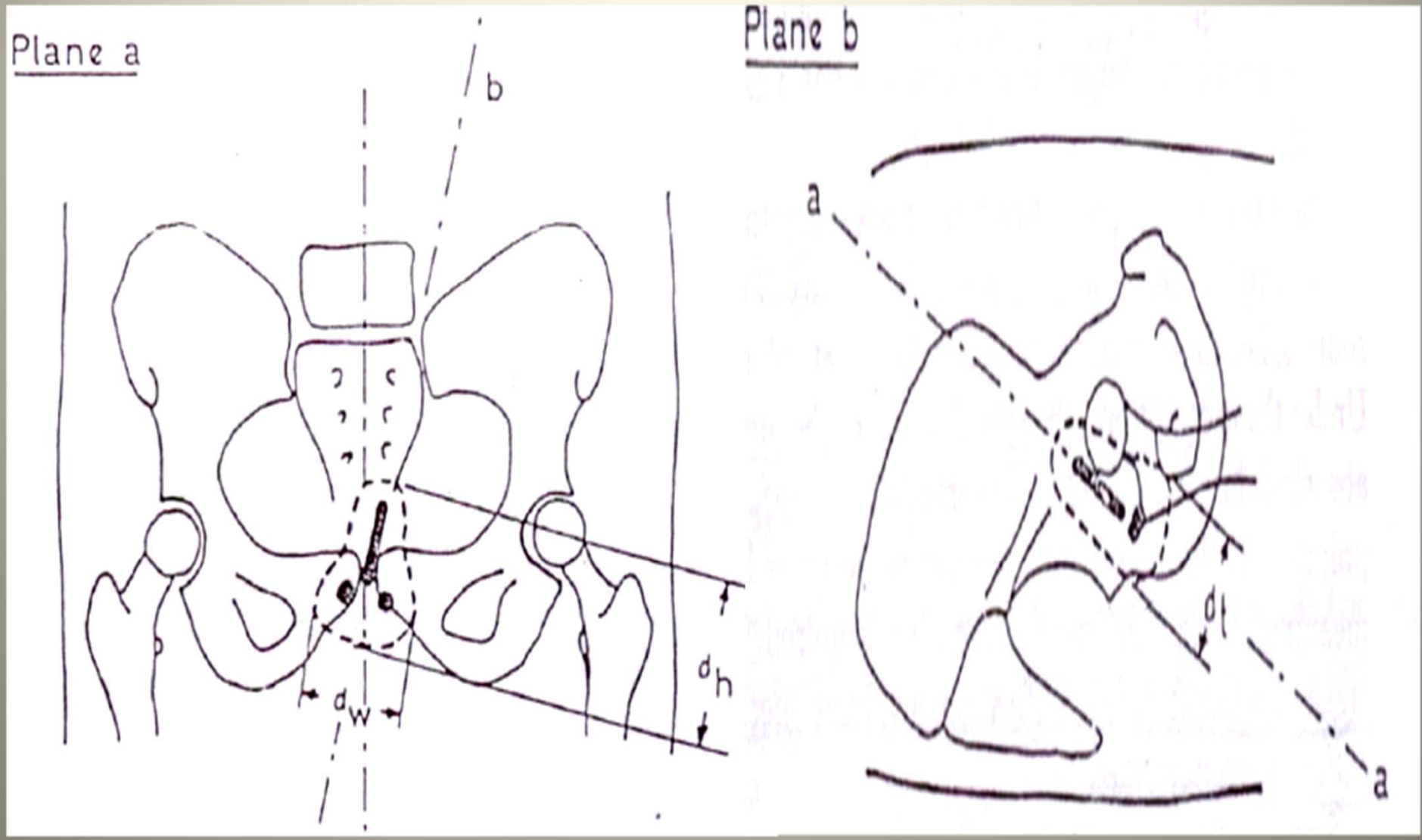
Height (d*h*) - *maximum dimension along intrauterine source measured in Oblique frontal plane containing intrauterine source*

Width (dw) - *maximum dimension perpendicular to intrauterine source measured in Oblique frontal plane containing intrauterine source*

Thickness (d*t*) - *maximum dimension perpendicular to intrauterine source measured in Oblique sagittal plane*

These dimensions are usually expressed in **cm**

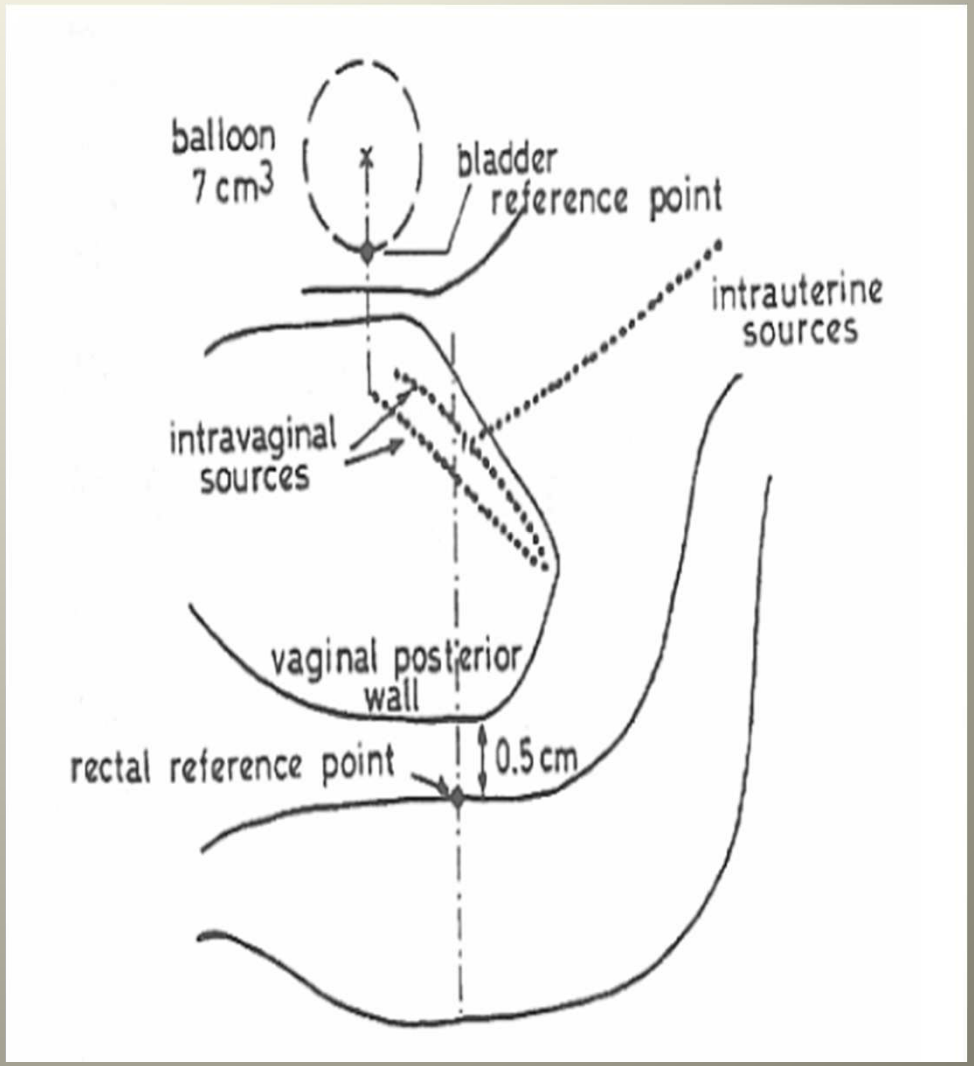
d*h* & d*w*



Bladder reference point

Lat X-ray – A-P line is drawn through the center of balloon Reference point is taken on this line at posterior surface of balloon

Frontal Xray – Point is taken at center of balloon

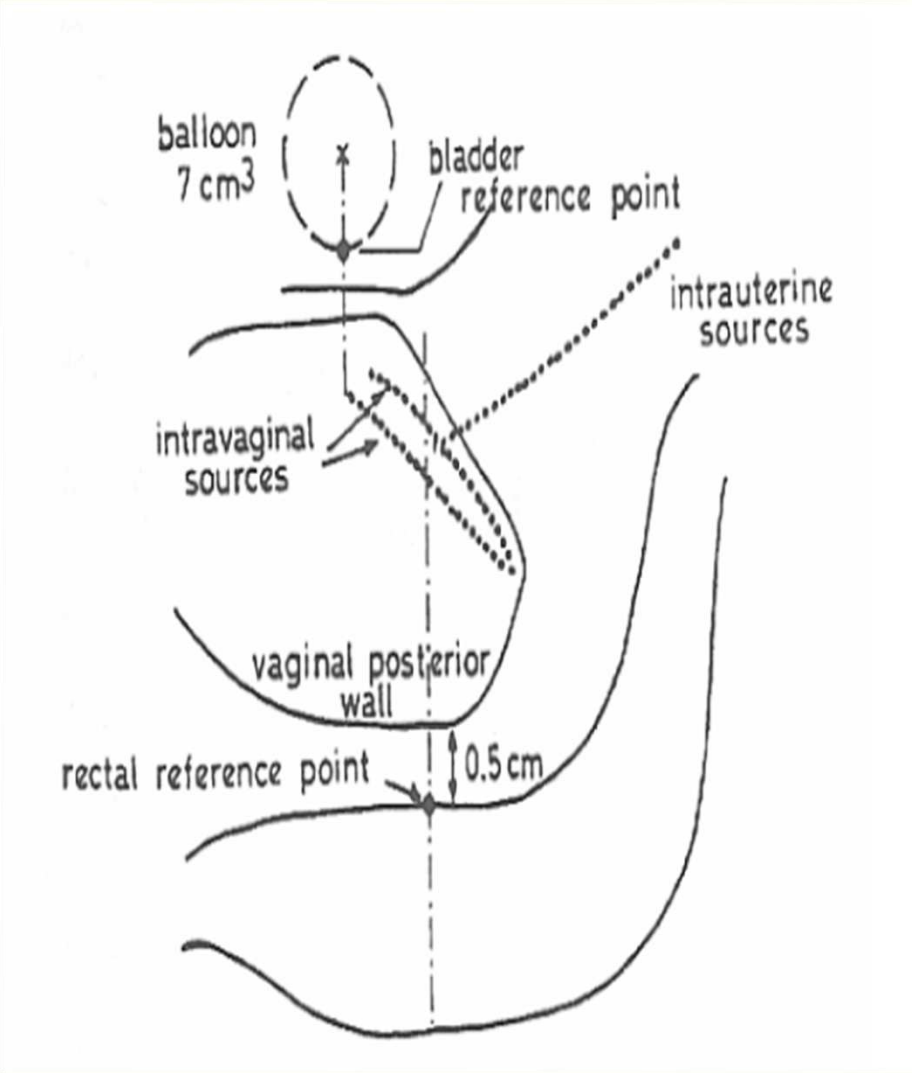


Rectal Reference point

- Lat Xray – A-P line drawn from lower end of intrauterine sources or from middle of intravaginal sources.

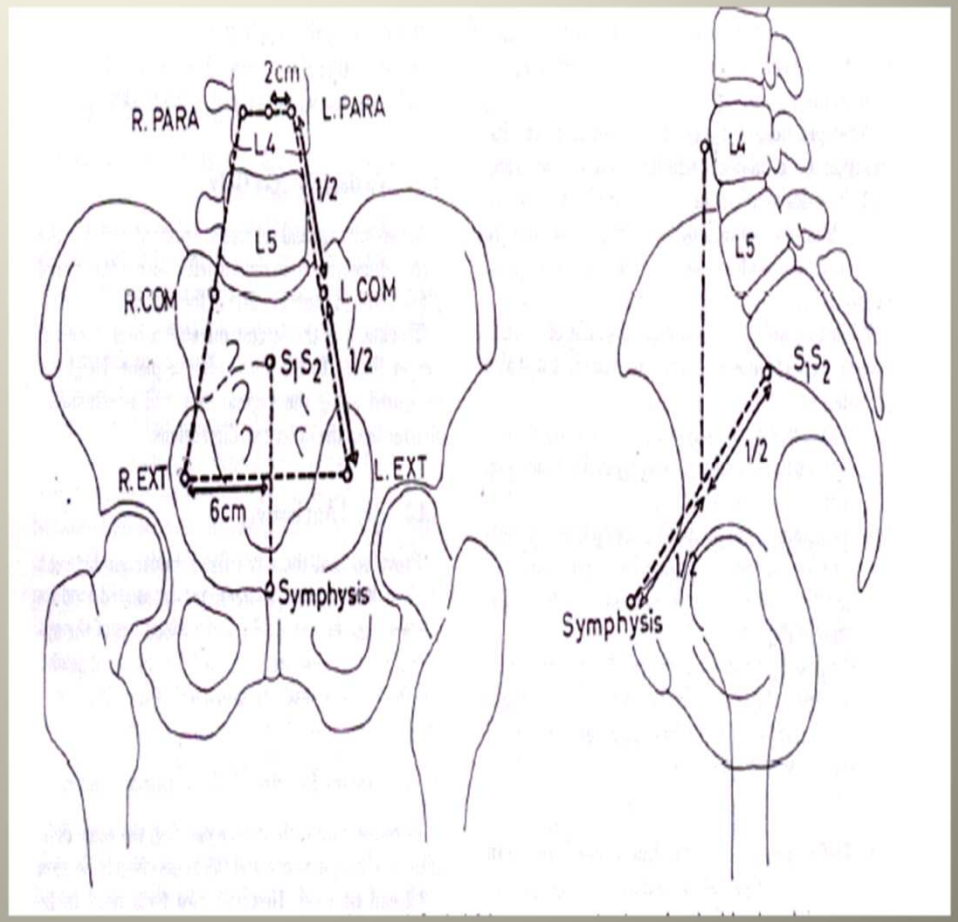
  Point is located on this line 0.5 cm behind the posterior vaginal wall.

  A-P Xray – Point is at lower end of intrauterine source or at middle of intravaginal sources.



The Lymphatic Trapezoid

- A Line drawn from S1-S2 junction to top of pubic symphysis, then line is drawn from middle of this line to middle of ant aspect of L4.
- A trapezoid is constructed in a plane passing through transverse line in pelvic brim plane and midpoint of ant aspect of L4 body

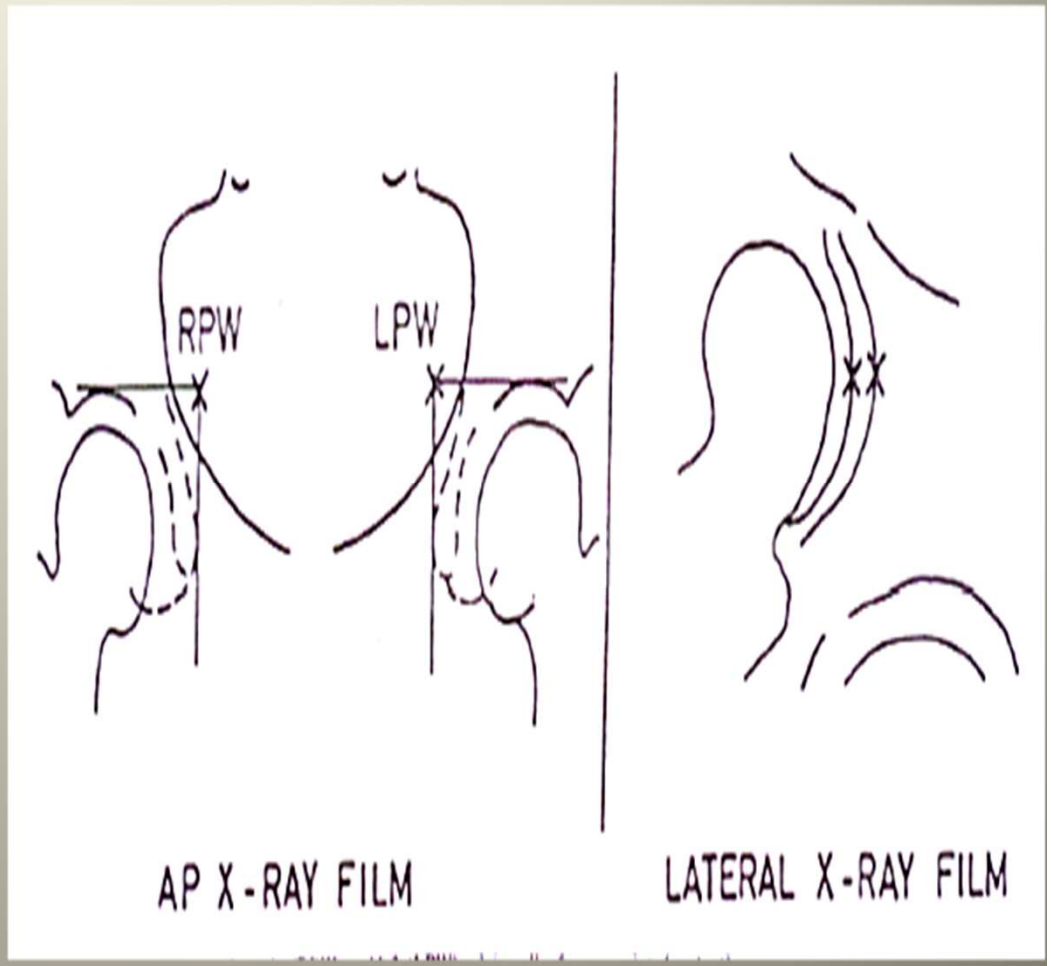


Lymphatic trapezoid represents dose at lower paraaortic, common iliac and external iliac lymph node

The Pelvic Wall Reference Point

On AP radiograph. Pelvic wall reference point is intersected by horizontal line tangential to the highest point of acetabulum and vertical line tangential to inner aspect of the acetabulum

On lateral radiograph the highest points of RT and LT acetabulum in the craniocaudal direction are joined and the lateral projection of PWRP is located at the mid-distance of these points



It is representative of absorbed dose at the distal part of the parametrium and at obturator nodes

THINGS TO REMEMBER –ICRU-38

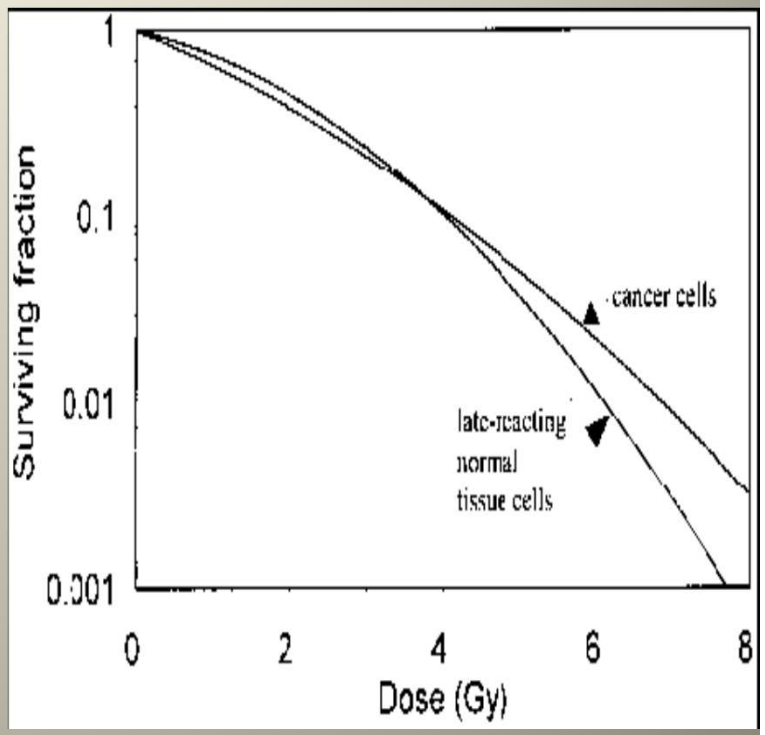
- Method of specification will be meaningful only when T/t technique is completely described.
- Reference volume be described in terms of height, width, thickness of volume enclosed in 60 Gy isodose surface for Ca- Cx T/t by LDR.
- Absorbed dose at reference point in organs at risk should be determined and expressed
- Absorbed dose at reference point related to bony structures should be reported.
- Time-dose pattern should be completely specified.

Transition from LDR to HDR

- LDR → HDR
- Physical advantages
  - Radiation protection
  - Reduced hospitalisation
  - Pt and staff convenience
  - Applicator
    - Stability
    - Aggressive packing
    - Narrow applicator
  - Optimisation

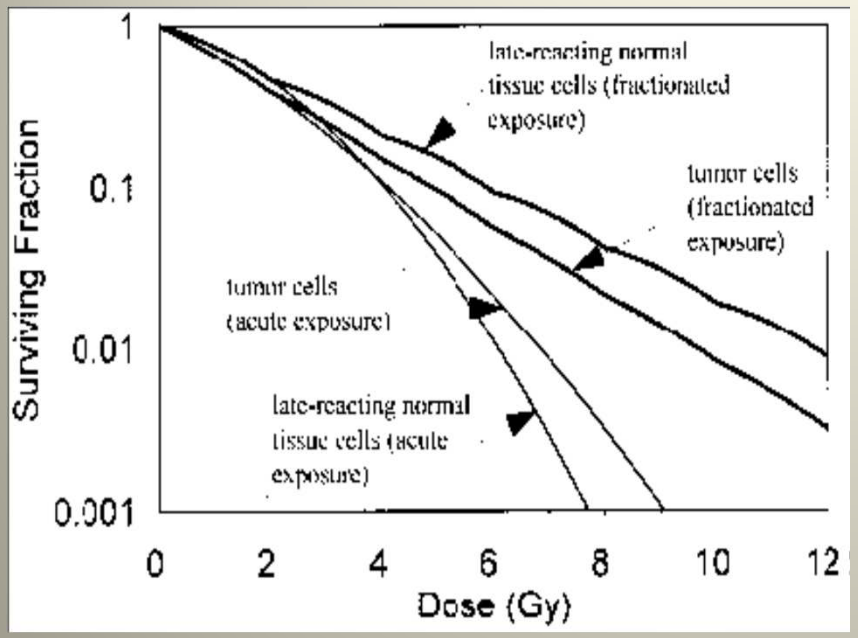
RADIOBIOLOGICAL BASIS OF BRACHTHERAPY

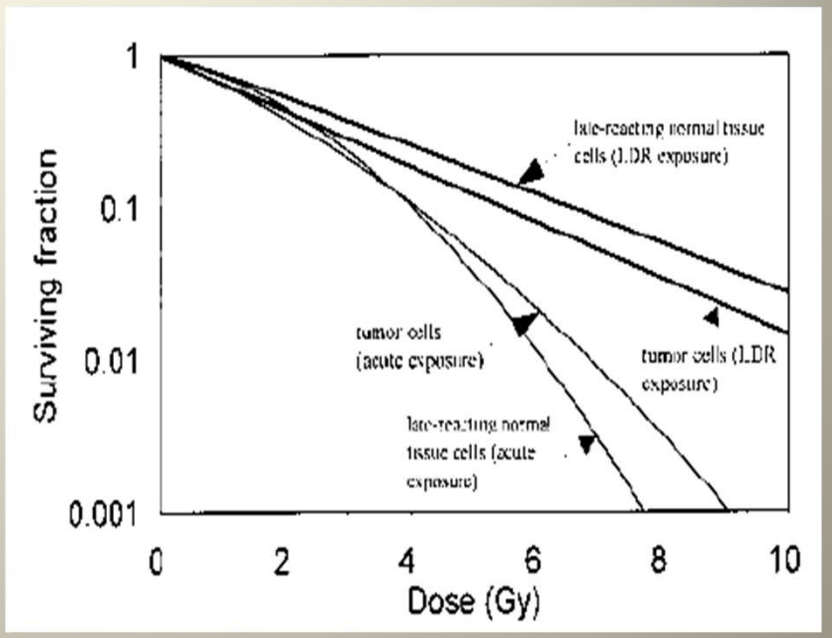
- Survival curves for late-reacting normal tissue cells tend to be curvier and to have a shallower initial slope compared to cancer cells
- At doses lower than those at the crossover point of the two curves, survival of normal cells exceeds that of tumor cells.
- However such low doses are not sufficient to kill all the cancer cells in a typical tumor, so multiple low-dose fractions have to be delivered, with enough time between fractions to allow for complete repair.



Typical log cell surviving fraction curves for late-reacting normal tissue and tumor cells irradiated acutely. The LQ model has been used to construct these curves with a:b values 2.5 Gy and 10 Gy for normal and tumor cells.

Low dose rate irradiation is considered to be an infinite no. of infinitely small #s which allows repair of SLD



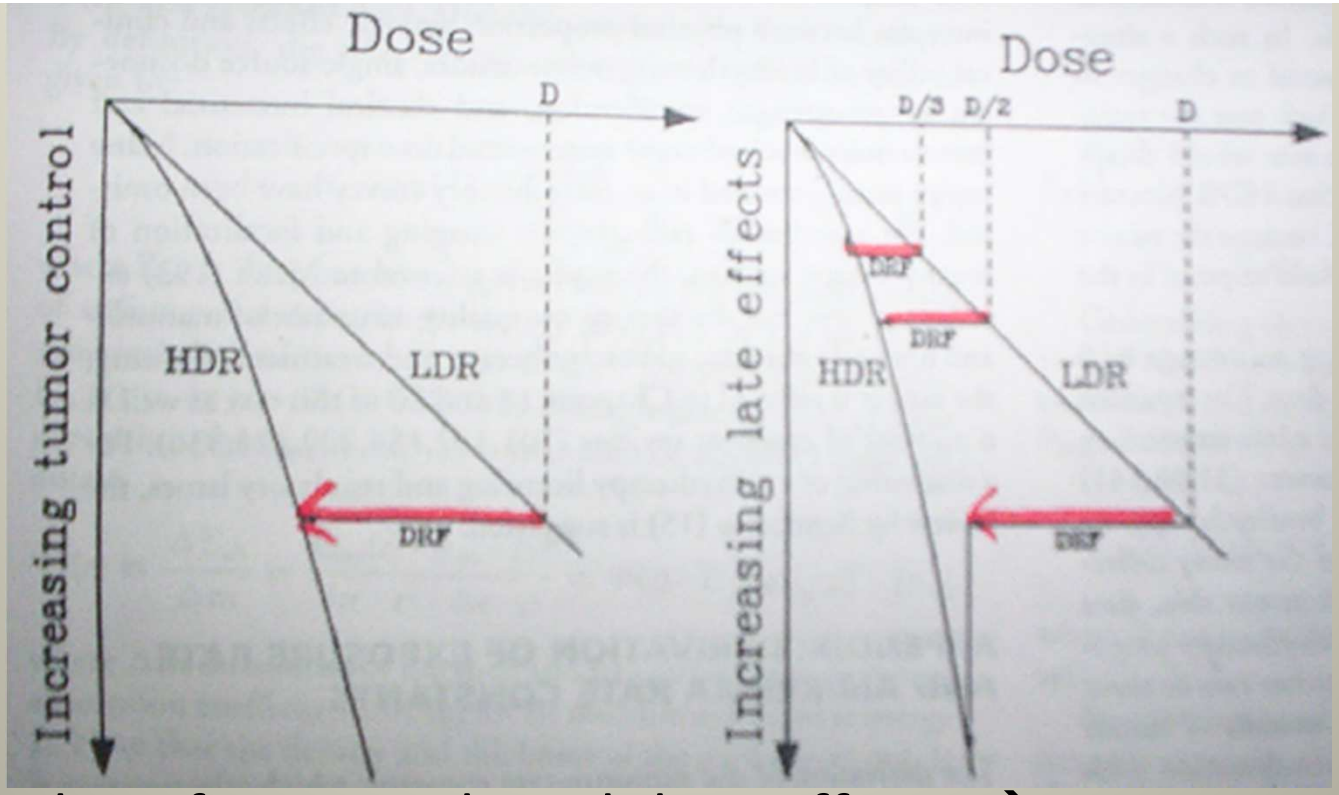


Fractionation with dose per fraction below the crossover point of the acutely exposed cells results in higher cell survival for late-reacting normal tissue compared to tumor cells

For each successive #s the curves diverge → therapeutic advantage

low LDR treatment results in higher cell survival for late-reacting normal tissue compared to tumor cells.

T1/2 repair of 0.5 and 1.5 h for tumor and normal-tissue cells, respectively, and dose rate 0.4 Gy:h for the LDR exposures



- Thus if we match with late effects → we accept some decrease in TC
- For a selected dose increase DR → late effects increase >>>> increase in TC
- Conversely decreasing DR → decrease late effects >>>> decrease in TC
- loss of therapeutic ratio when regimens of logistic convenience (HDR) are used (Fowler)
- But carcinoma cervix is an exception to this rule

Carcinoma cervix …. A special case

- Dose limiting organs at risk (rectum & bladder) are some distance away from the source
- In cervix the dose limiting normal tissues receive a lower dose than the prescribed dose to the tumor (pt A)
- For HDR its possible to use retractors and packing that result in lower doses to the rectum and bladder than are possible with an insertion that lasts for hrs in LDR (additional 20%)
- This physical advantage offsets the radiobiological disadvantages
- Thus, LDR → HDR conversion is based on matching TC than late effects.
- Conversion from LDR to HDR the total dose to Point A was reduced on average by a factor 0.54 +/- 0.06 DRF/conversion factor.

Orton CG ,IJROBP,1991

TMH Protocol

STAGE	EBRT	LDR BRACHY	HDR BRACHY	TOTAL DOSE TO Pt 'A"
IB – IIA	40Gy/20#	30Gy X 2#	7Gy X 5#	80 – 85Gy
II B	40Gy/20#	30Gy X 2#	7Gy X 5#	80 – 85Gy
IIIB – IVA	50Gy/25#	30Gy X 1#	7Gy X 3#	85 – 90Gy

$$\text{For HDR:} \quad \text{BED} = Nd\left(1 + \frac{d}{\alpha/\beta}\right)$$

$$\text{For LDR:} \quad \text{BED} = NRt\left[1 + \frac{2R}{\mu(\alpha/\beta)}\left\{1 - \frac{1 - e^{-\mu t}}{\mu t}\right\}\right] \tag{2}$$

$$S = e^{-\alpha.\text{BED}} \tag{3}$$

where:

BED = biologically effective dose
N = number of fractions (of HDR or LDR)
d = dose per fraction (in Gy)
α = L–Q model "irreparable damage" parameter
β = L–Q model "repairable damage" parameter
R = dose rate in Gy/h (for LDR)
t = time (in h) for each LDR fraction
μ = repair rate constant (in h^{-1}) = $0.693/t_{1/2}$
S = cell surviving fraction

- R → R.f
- d → d.f

COLIN G. ORTON,

CHANGE FROM LOW-DOSE-RATE (LDR) TO HDR (T C)

- Problem: What dose/fraction of HDR delivered in six fractions will be equivalent in terms of tumor control to 60 Gy delivered to Point A at 0.55 Gy h-1?
- Solution: Assume α/β(tumor) = 10 Gy, μ(tumor) = 0.46 h-1.
- Then: BED (LDR) = $60[1 + (2 \times 0.55)/(0.46 \times 10)] = 74.3$
- Equating this to the BED for 6 HDR fractions with dose/fraction *d* gives:
- $74.3 = 6d(1 + d/10)$
- Solving this quadratic equation for *d* gives: $d = 7.20$ Gy.
- Conclusion: 6 fractions of 7.20 Gy with HDR is equivalent in terms of tumor control to 60 Gy delivered at 0.55 Gy h-1.

EFFECT OF CHANGE TO HDR ON LATE EFFECTS

- Problem: If it is assumed that the effective dose to rectal/bladder tissues in the above example is 75% of the Point A dose for the LDR treatments (i.e., the geometric sparing factor, *f*, is 0.75), what geometric sparing factor is required for the HDR treatments in order for the two regimes to be equivalent in terms of late reactions?

- Solution: Assume α/β(late) = 3 Gy, μ(late) = 0.46 h-1 , t1/2= 1.5 hr.
- Then: BED (LDR) = $60 \times 0.75[1 + (2 \times 0.55 \times 0.75)/(0.46 \times 3)] = 71.9$.

- Equating this to the BED for HDR with sparing factor *f* gives:
- $71.9 = 6 \times 7.20 f (1 + 7.20f/3)$.

- Solving this quadratic equation for *f* gives: $f = 0.65$.

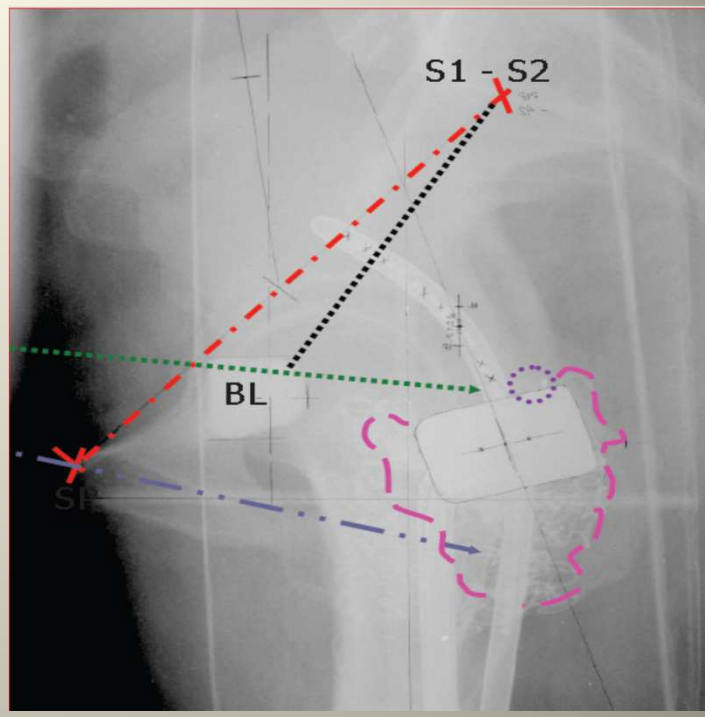
- Conclusion: To keep the risk of late normal tissue damage constant in the above conversion from LDR to HDR, it is necessary to reduce the effective dose to rectal/bladder tissues to about 65% of the Point A dose.

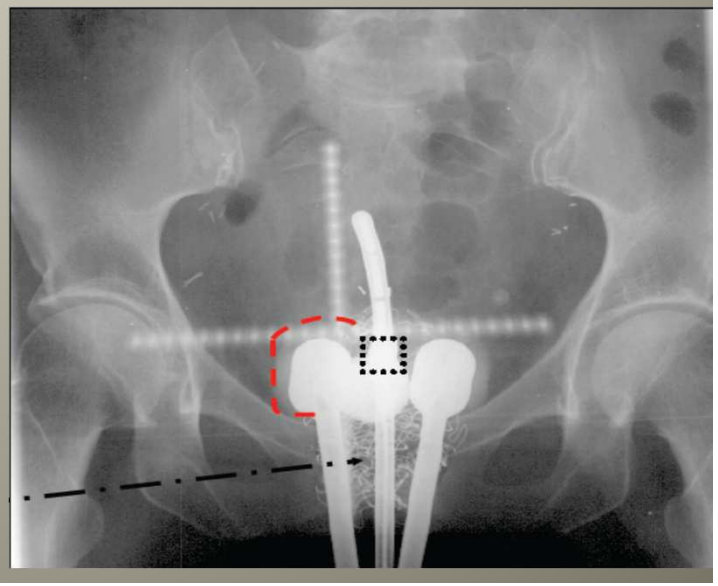
Planning

- Imaging modalities used for Image Based ICRT planning :
- 2D Planning : Orthogonal X-ray Based
- 3D Planning :
    - USG
    - CT Scan
    - MRI
    - PET

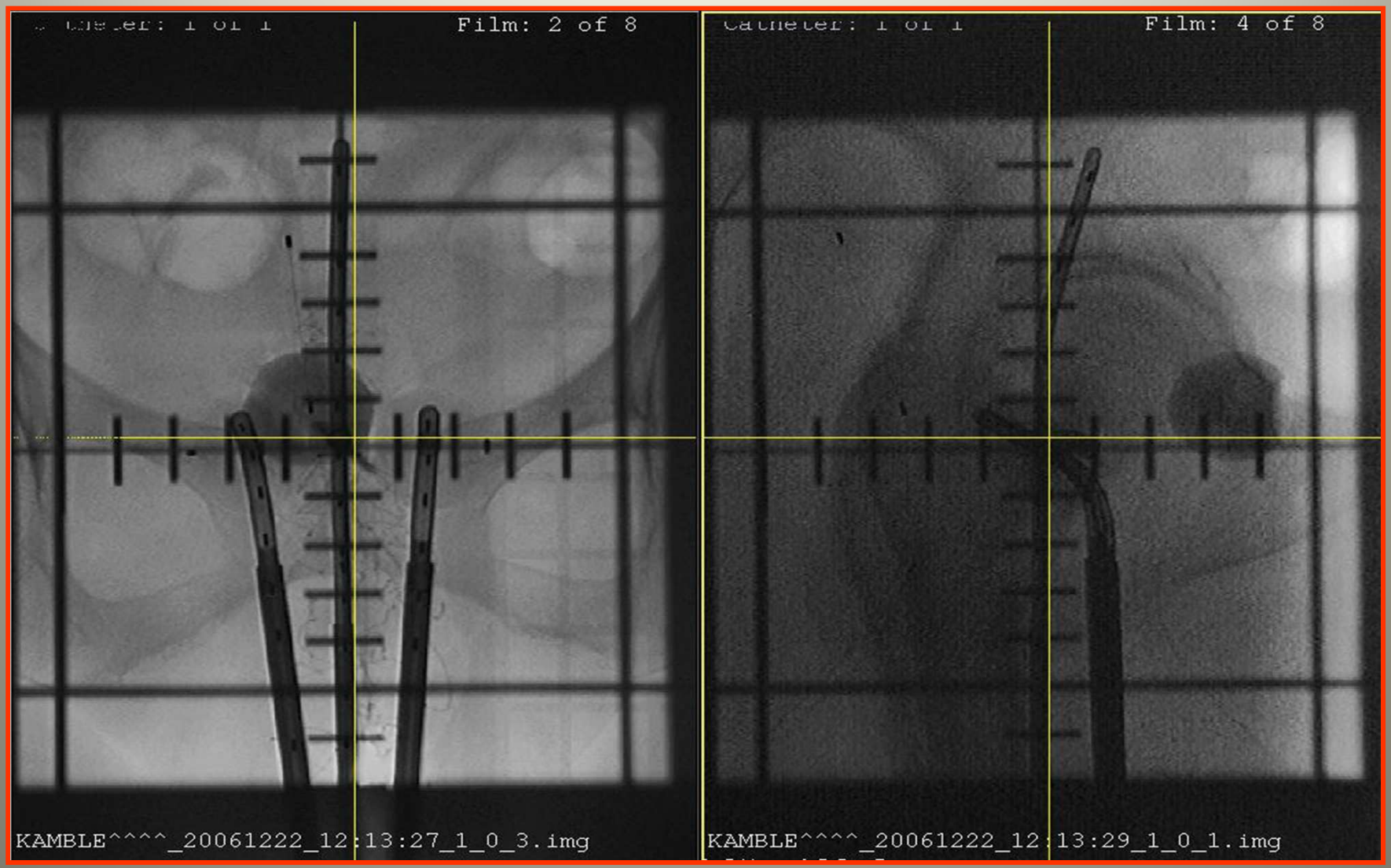
IDEAL APPLICATION

- Tandem
  - 1/3 of the way between S1 –S2 and the symphysis pubis
  - Midway between the bladder and S1 -S2
  - Bisect the ovoids
- Marker seeds should be placed in the cervix
- Ovoids
  - against the cervix (marker seeds)
  - Largest
  - Separated by 0.5-1.0 cm
  - Axis of the tandem-central
- Bladder and rectum -should be packed away from the implant



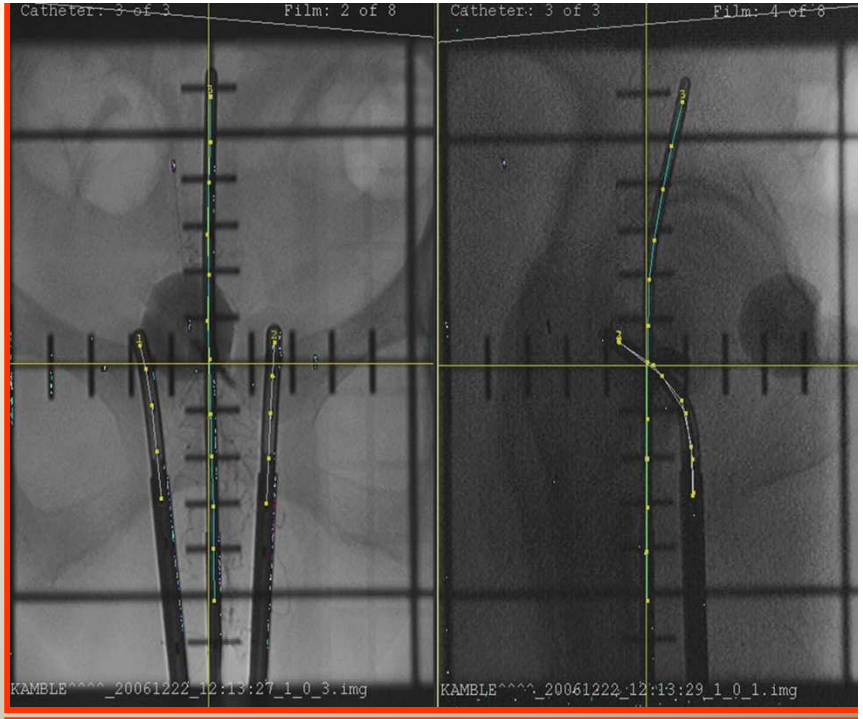


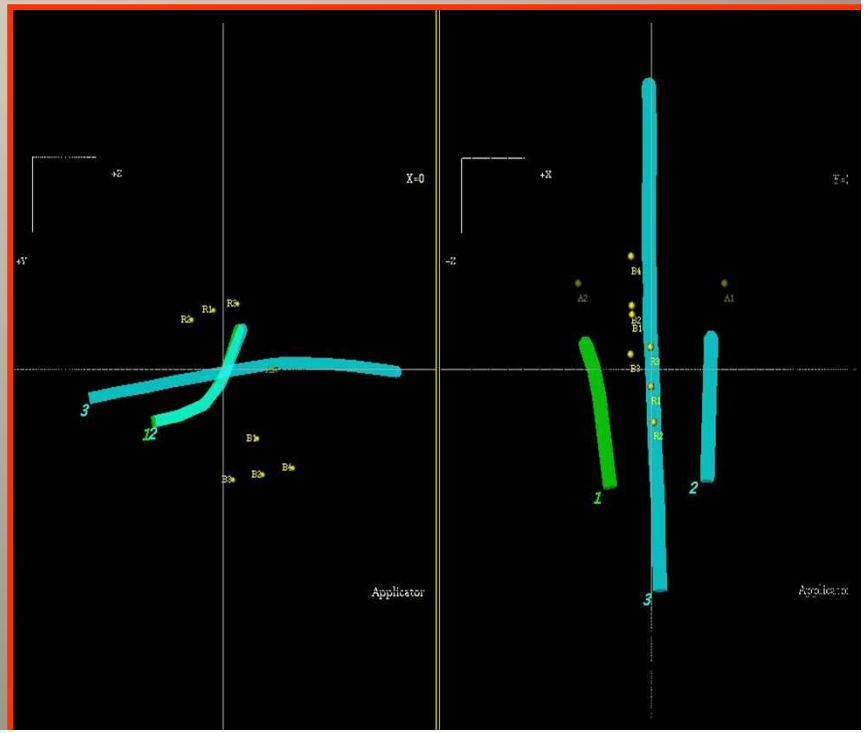
Orthogonal radiographs



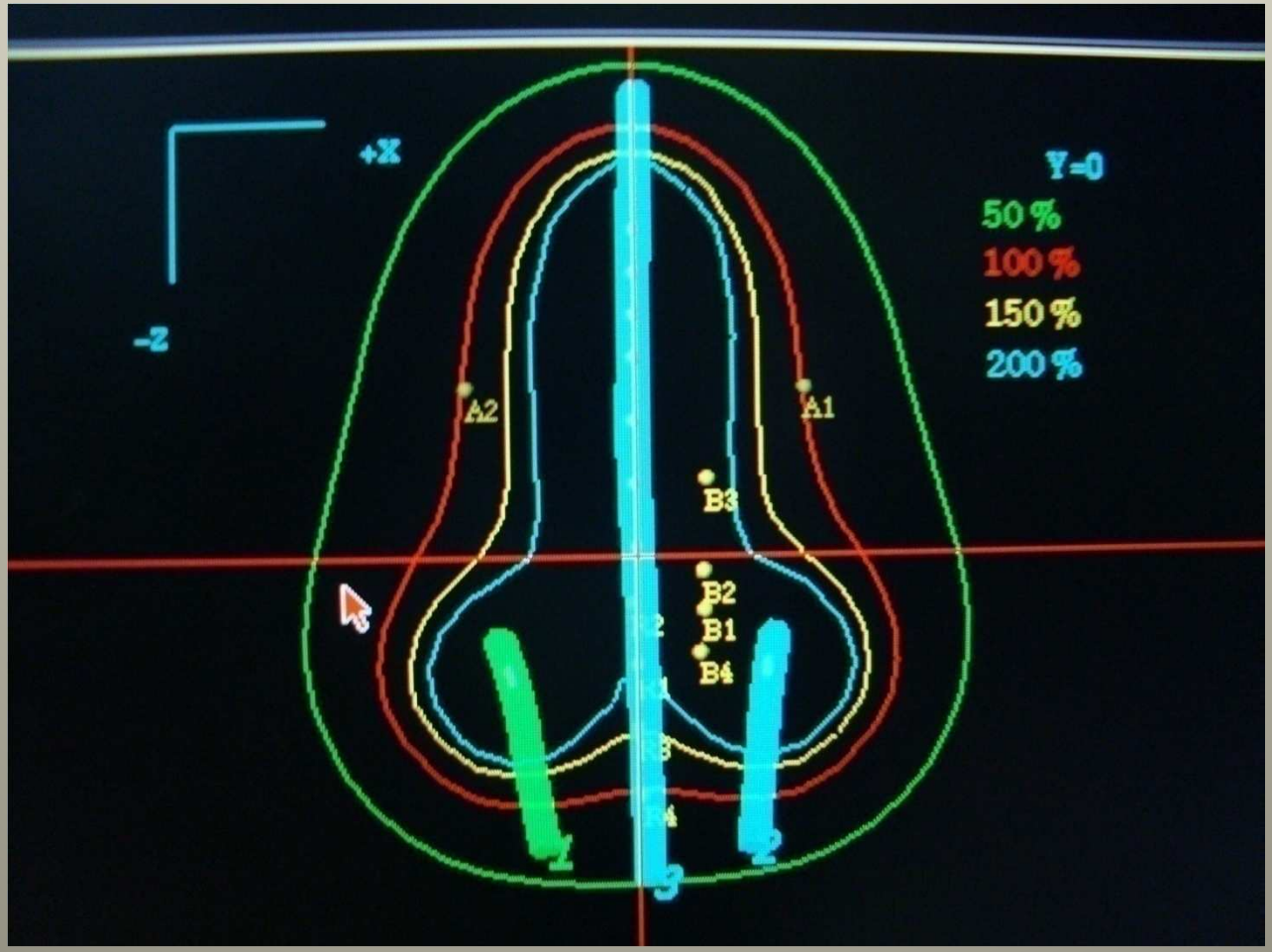
Dosimetry

- Mark the posterior vaginal wall
- Digitization/reconstruction of applicator dummies
- Rectal and Bladder points
- Definition of point A
- Loading the source positions
- Plan evaluation
- Optimisation





Isodose Distribution



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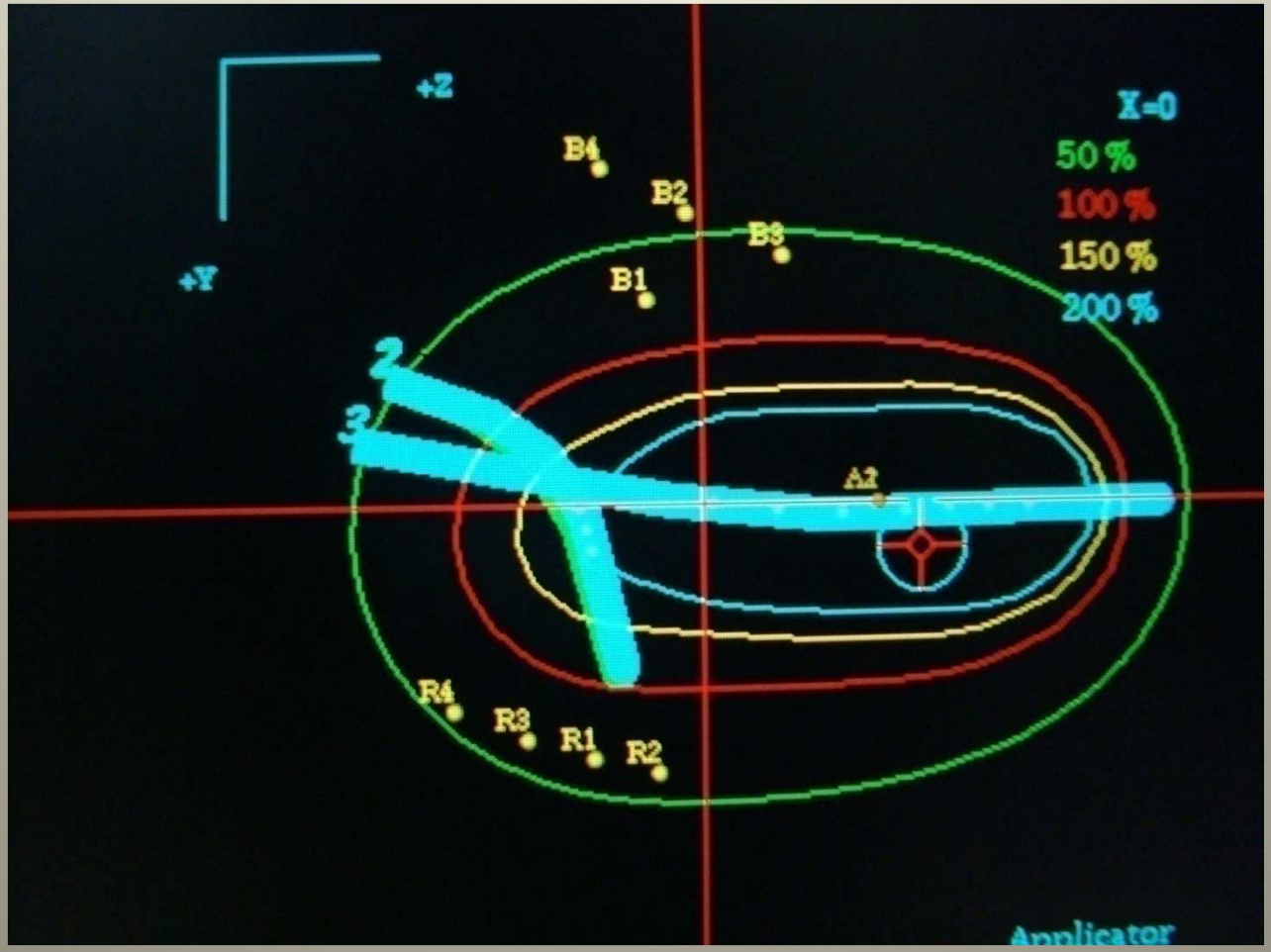
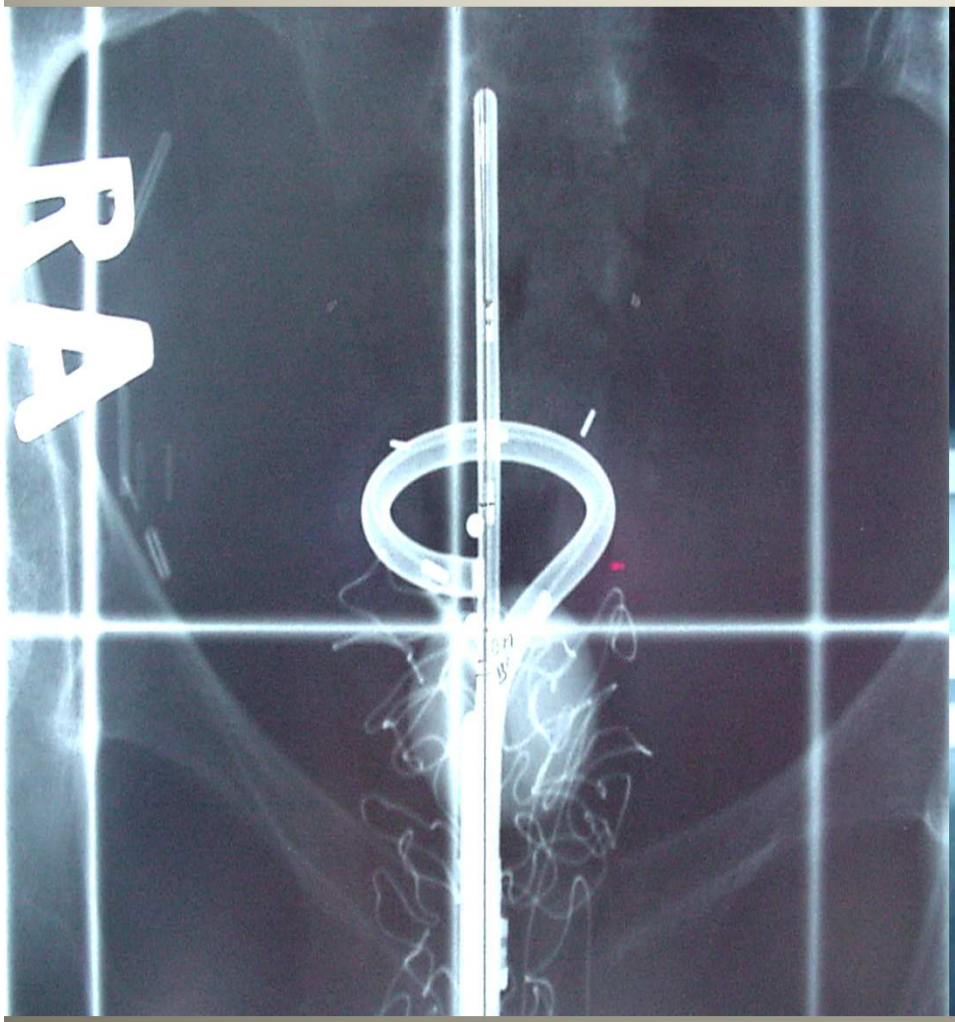
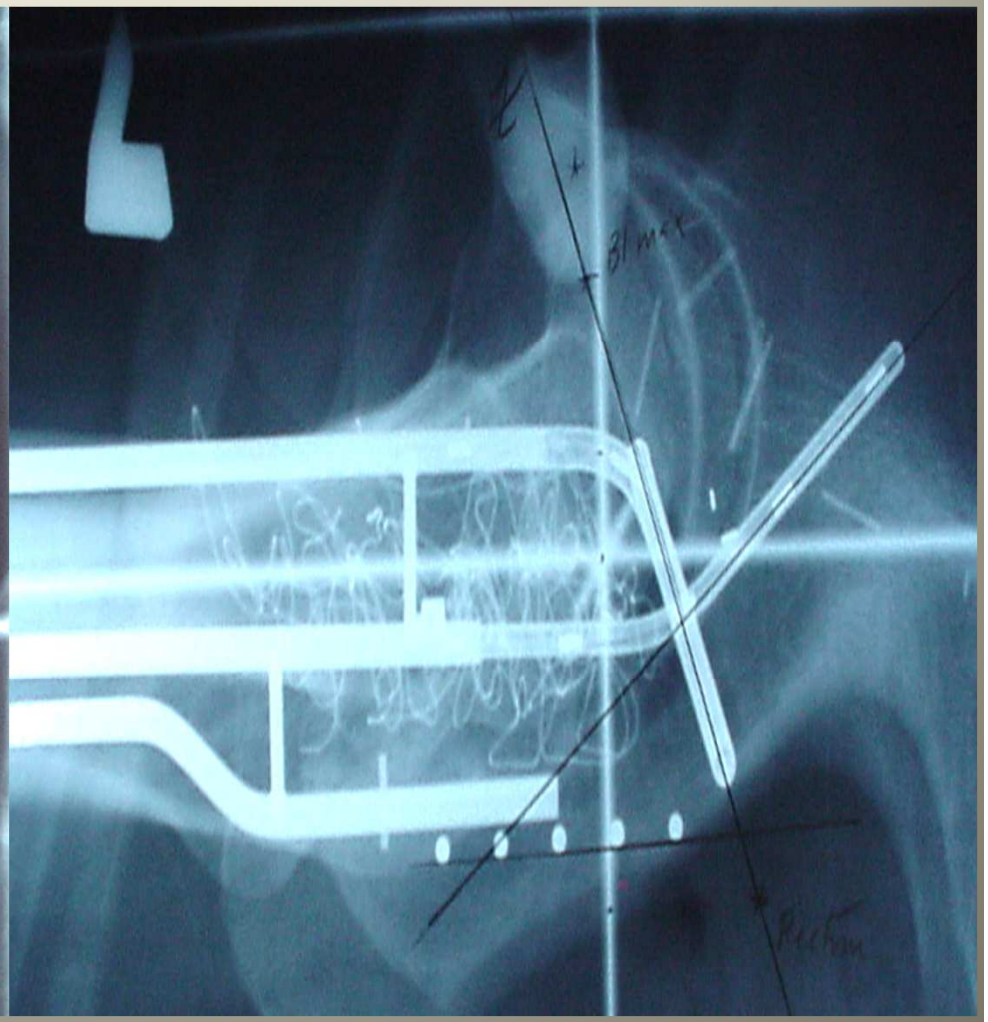


Ring Applicator





Comparison of high and low dose rate remote afterloading for cervix cancer and the importance of fractionation

Orton CG, r Int J Radiat Oncol Biol Phys. 1991 Nov;21(6):1425-34

- Analysis of the data obtained from a survey of 56 institutions
- 17,000 pts with RAL HDR
- Avg. fractionation regimen = 7.5 Gy/5# each to Point A, regardless of stage of disease

Comparison of high and low dose rate remote afterloading for cervix cancer and the importance of fractionation

Orton CG, r Int J Radiat Oncol Biol Phys. 1991 Nov;21(6):1425-34

5 yr Sx	Stg III	All pts
HDR	47.2%	60.8%
LDR	42.6%	59%
P value	< 0.001	0.045

morbidities	severe	moderate
HDR	2.23%	9.05%
LDR	5.34%	20.1%
P value	<0.001	<0.001

- Apparent geometrical advantage
  - Reduction in the **hot spot** rectal and bladder doses on an avg. 13+/-4 % for HDR as compared to LDR

Comparison of high and low dose rate remote afterloading for cervix cancer and the importance of fractionation

Orton CG, r Int J Radiat Oncol Biol Phys. 1991 Nov;21(6):1425-34

Table 4

Patient distribution and 5-year (crude) survival data determined in the meta-analysis of the Ca cervix brachytherapy results from 56 institutions by Orton, et al. (30)

Stage	HDR patients	LDR patients	5-year survival		p-value
			HDR (%)	LDR (%)	
I	1 327	630	82.7	82.4	>0.05
II	2 891	1 271	66.6	66.8	>0.05
III	2 721	1 464	47.2	42.6	0.005
IV	221	56	20.4	14.3	>0.05
Overall	7 468	4 738	60.8	59.0	0.045

Comparison of high and low dose rate remote afterloading for cervix cancer and the importance of fractionation

Orton CG, r Int J Radiat Oncol Biol Phys. 1991 Nov;21(6):1425-34

- Sig. effect of dose #nation on toxicities
- The effect of dose/fraction on cure rates was equivocal.
- Conversion from LDR to HDR the total dose to Point A was reduced on average by a factor 0.54 +/- 0.06.

Morbidities	Severe	Sev & mod.
< 7 Gy	1.28%	7.58%
> 7 Gy	3.44%	10.54%
P value	<0.001	<0.001

LDR Vs HDR in the treatment of carcinoma cervix : a clinical trial

Patel FD, Sharma SC IJROBP 1994; 28: 335-9 PGI Chandigarh

- Prospective randomised controlled trial
- June 1986 – June 1989, 482 patients
- 246 pts LDR and 236 pts HDR arm
- Pts were analysed for LC , 5 yr survival and late radiation morbidities.
- Grp I =
  - 35Gy EBRT(MLB) + 37.5GyX 2# to pt A
  - 35Gy EBRT(MLB) + 9.5GyX 4# to pt A
- Grp II =
  - 45Gy EBRT + 35GyX 1# to pt A
  - 45Gy EBRT + 9GyX 2# to pt A

LDR Vs HDR in the treatment of carcinoma cervix : a clinical trial

Patel FD, Sharma SC IJROBP 1994; 28: 335-9

	LC	5yr Sx stage I	5yr Sx stage II	5yr Sx stage III	Over all rectal comp.	Gr III/IV Rectal comp.
LDR arm	79.8 %	73%	62%	50%	19.9 %	2.4%
HDR arm	75.8 %	78%	64%	43%		0.4%

HIGH-DOSE-RATE BRACHYTHERAPY IN UTERINE CERVICAL CARCINOMA FIRUZA D. PATEL, M.D., BHAVANA RAI, M.D., DIP.N.B., INDRANIL MALLICK, M.B.B.S., AND SURESH C. SHARMA, M.D.

Department of Radiotherapy, Postgraduate Institute of Medical Education and Research, Chandigarh, India

	Local failure	Distant failure
Grp I	11%	None
Grp II	21%	8.4%

- None of the pts dev gr III rectal complications
- 3 pts dev grd III bladder toxicities

- Conclusion: HDR brachytherapy at 9 Gy/fraction is both safe and effective in the management of carcinoma of the cervix, with good local control and a minimum of normal tissue toxicity.

THE AMERICAN BRACHYTHERAPY SOCIETY RECOMMENDATIONS FOR HDR BRACHYTHERAPY FOR CARCINOMA OF THE CERVIX

Int. J. Radiation Oncology Biol. Phys., Vol. 48, No. 1, pp. 201–211, 2000

- Definitive irradiation for cervical carcinoma must include brachytherapy as a component.
-
- The goals are to treat Point A to at least a total low-dose-rate (LDR) equivalent of 80–85 Gy for early stage disease and 85–90 Gy for advanced stage.
- The pelvic sidewall dose recommendations are 50–55 Gy for early lesions and 55–65 Gy for advanced ones.
- The ABS recommends keeping the total treatment duration to less than 8 weeks

THE AMERICAN BRACHYTHERAPY SOCIETY RECOMMENDATIONS FOR HDR BRACHYTHERAPY FOR CARCINOMA OF THE CERVIX

Int. J. Radiation Oncology Biol. Phys., Vol. 48, No. 1, pp. 201–211, 2000

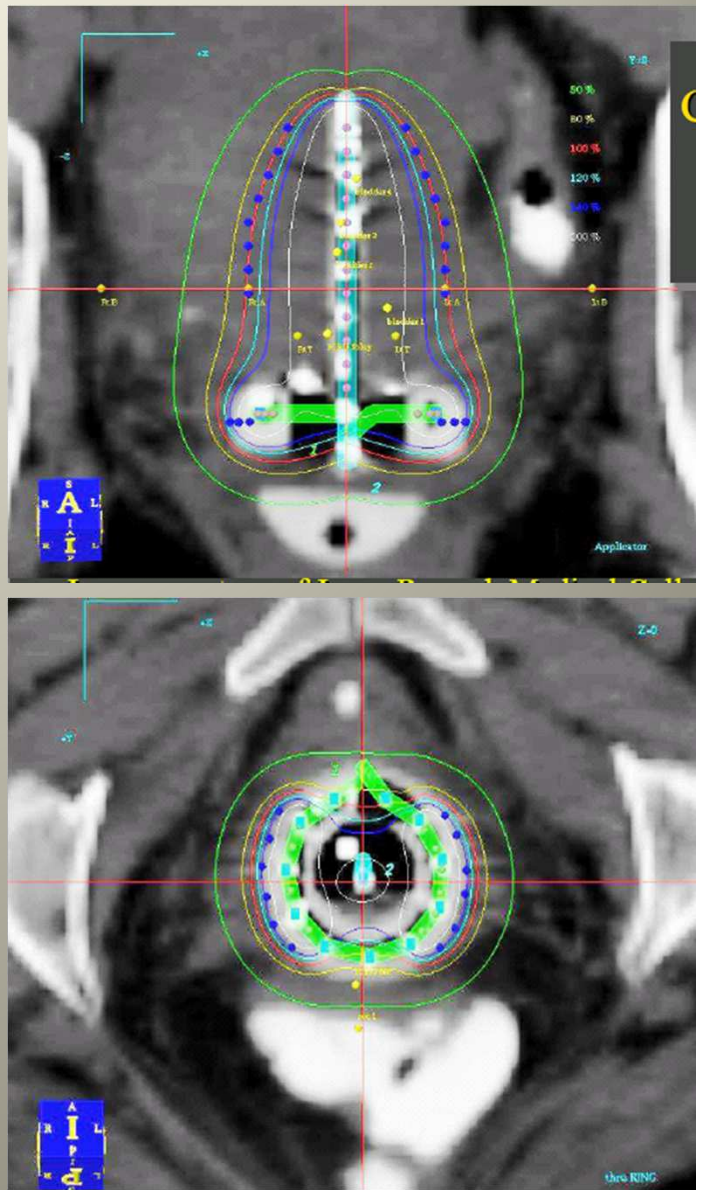
- Every attempt should be made to keep the bladder and rectal doses below 80 Gy and 75 Gy LDR equivalent doses, respectively.
- Extra care must be taken to ensure adequate bladder and rectal packing when using high dose (>7 Gy)per fraction.
- Interstitial brachytherapy should be considered for patients with disease that cannot be optimally encompassed by intracavitary brachytherapy.

Drawbacks of 2D Planning

- Target Volume assessment → Exact disease extent not known
- Limitations of Point A
- Delineation of Organs at risk
    - Rectum
    - Bladder
    - Sigmoid
    - Small intestine
    - Vaginal mucosa

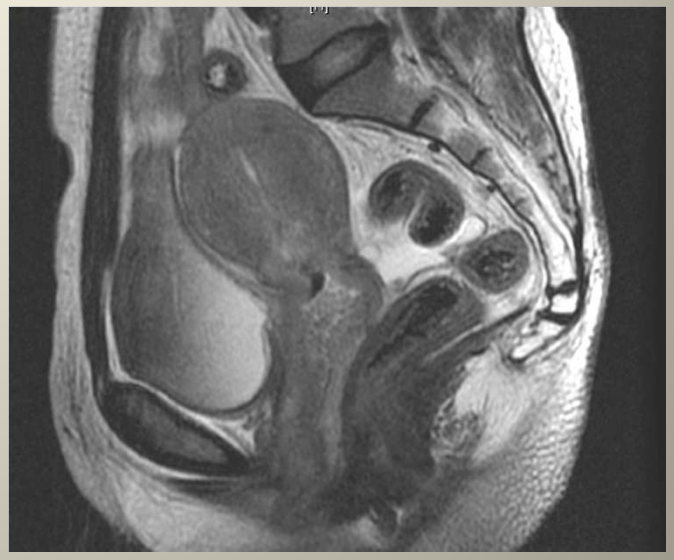
CT Scan Based Planning

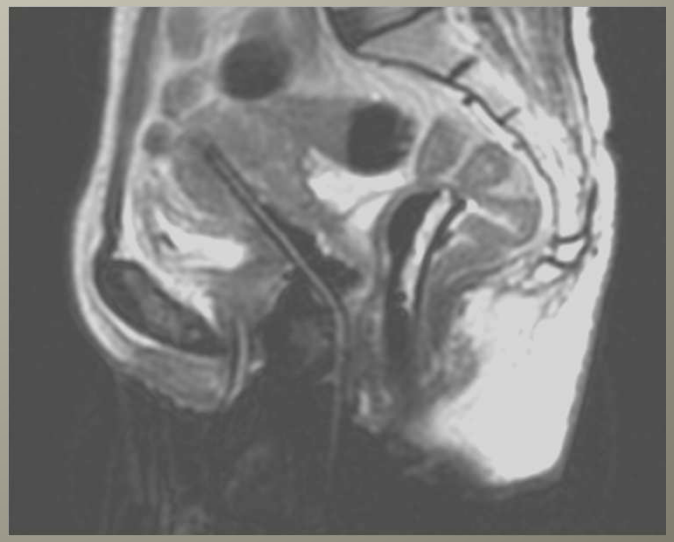
- Bladder and Rectum visualization better
- Applicator Reconstruction : Easy
- Limitations:
  - Metal artifacts → special applicator
  - Poor differentiation b/w uterus, parauterine tissue, cervix and tumor.



MRI Based Brachytherapy Planning

- Good soft tissue contrast
- True multiplanar imaging
- Differentiation between cervix, uterus, tumor and parauterine tissue
- Rectum, bladder, sigmoid and small intestine visualized
- Limitations:
  - Expensive
  - Special applicator
  - logistics





ATTEMPT AT 3D IMAGE BASED ICBT

GEC ESTRO IN 2000 FOUNDED A WORKING GROUP

GYN GEC ESTRO WG

To support 3D imaging based 3D treatment planning approach in carcinoma cervix.

ELSEVIER

Radiotherapy and Oncology 74 (2005) 235–245

RADIOTHERAPY & ONCOLOGY
JOURNAL OF THE EUROPEAN SOCIETY FOR THERAPEUTIC RADIOLOGY AND ONCOLOGY

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Recommendations from Gynaecological (GYN) GEC-ESTRO Working Group☆ (I): concepts and terms in 3D image based 3D treatment planning in cervix cancer brachytherapy with emphasis on MRI assessment of GTV and CTV

Christine Haie-Meder[a,*], Richard Pötter[b], Erik Van Limbergen[c], Edith Briot[a], Marisol De Brabandere[c], Johannes Dimopoulos[b], Isabelle Dumas[a], Taran Paulsen Hellebust[d], Christian Kirisits[b], Stefan Lang[b], Sabine Muschitz[b], Juliana Nevinson[e], An Nulens[c], Peter Petrow[f], Natascha Wachter-Gerstner[b]

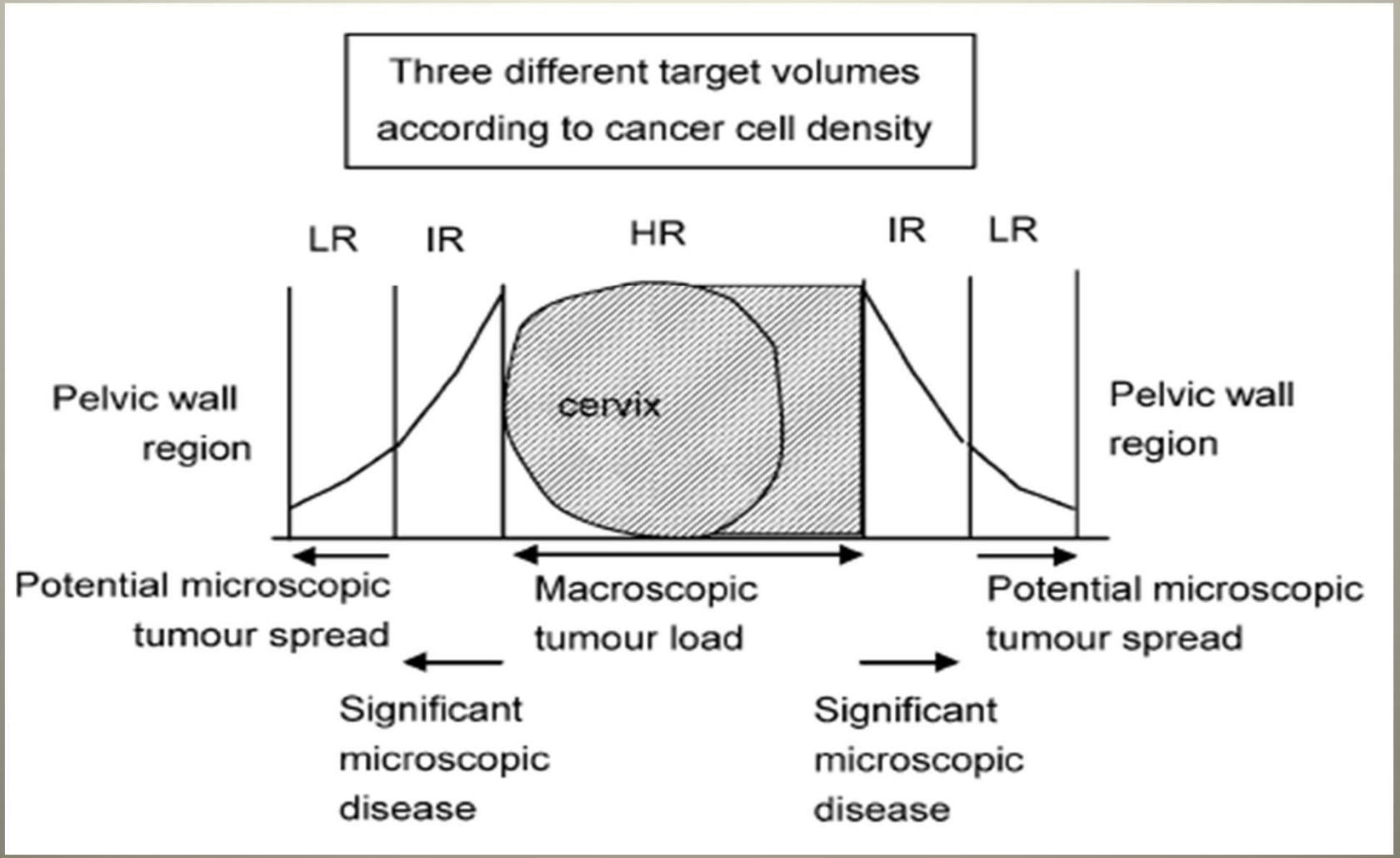
ESTRO project

Recommendations from gynaecological (GYN) GEC ESTRO working group (II): Concepts and terms in 3D image-based treatment planning in cervix cancer brachytherapy—3D dose volume parameters and aspects of 3D image-based anatomy, radiation physics, radiobiology

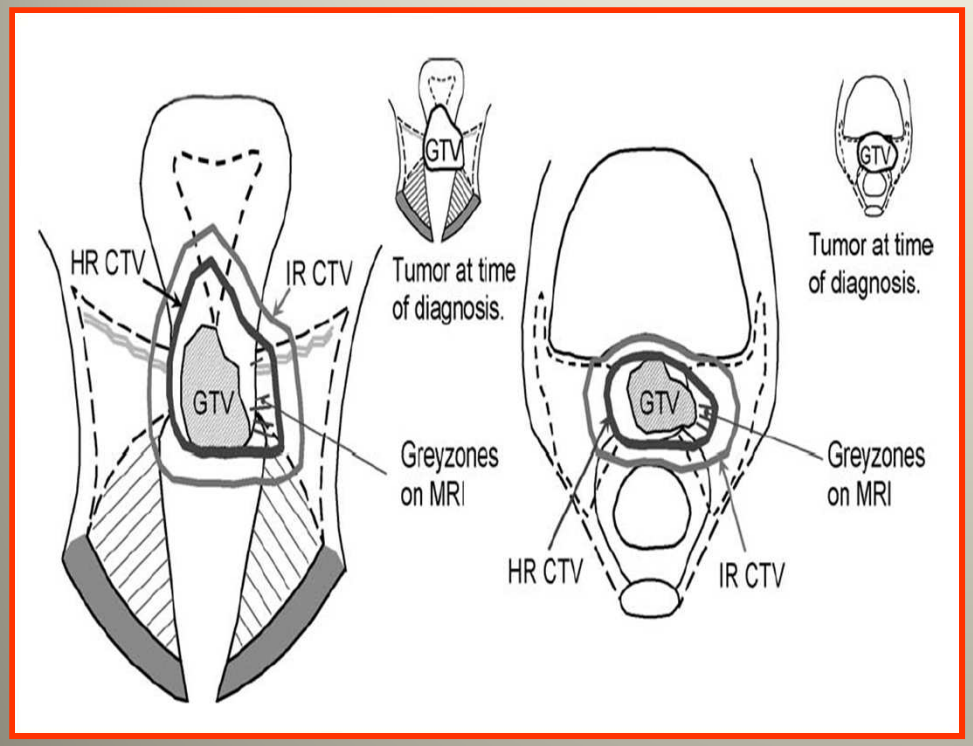
Richard Pötter[a,*], Christine Haie-Meder[b], Erik Van Limbergen[c], Isabelle Barillot[d], Marisol De Brabandere[c], Johannes Dimopoulos[a], Isabelle Dumas[b], Beth Erickson[e], Stefan Lang[a], An Nulens[c], Peter Petrow[f], Jason Rownd[e], Christian Kirisits[a]

[a]*Department of Radiotherapy and Radiobiology, Medical University of Vienna, Austria,* [b]*Department of Radiotherapy, Brachytherapy Unit, Institut Gustave Roussy, Villejuif, France,* [c]*Department of Radiotherapy, University Hospital Gasthuisberg, Leuven, Belgium,* [d]*Department of Radiation Oncology, Centre George-Francois Leclerc, Dijon, France,* [e]*Department of Radiation Oncology, Medical College of Wisconsin, Milwaukee, WI, USA,* [f]*Service de Radiodiagnostic, Institut Curie, Paris, France*

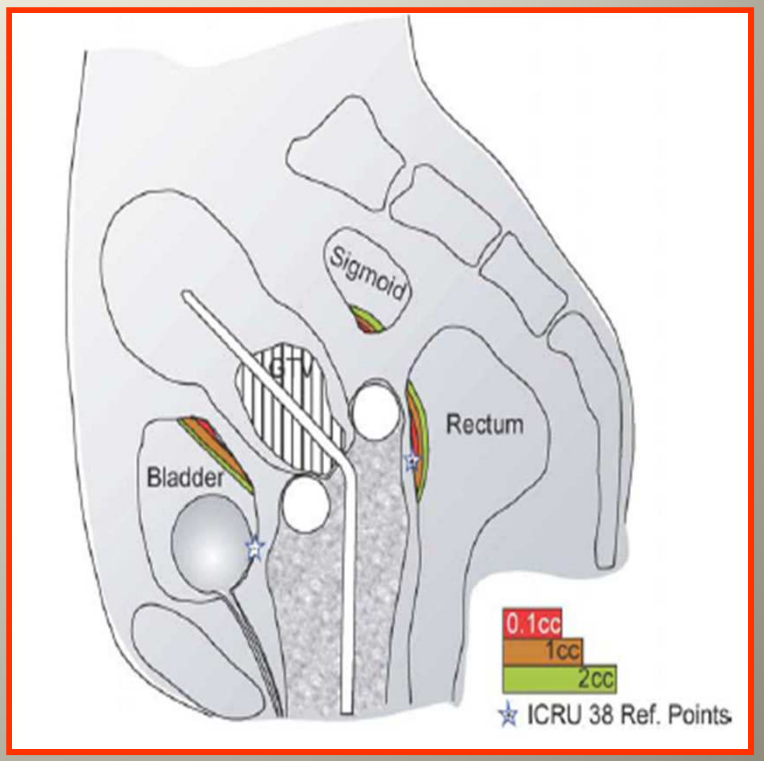
GEC ESTRO RECOMMENDATIONS



GEC ESTRO RECOMMENDATIONS



D100, D90 for GTV, HR CTV, IR CTV



D0.1cc, D1cc, D2cc for OARs

Radiotherapy and Oncology 78 (2006) 67–77

DEFINITION OF GTV

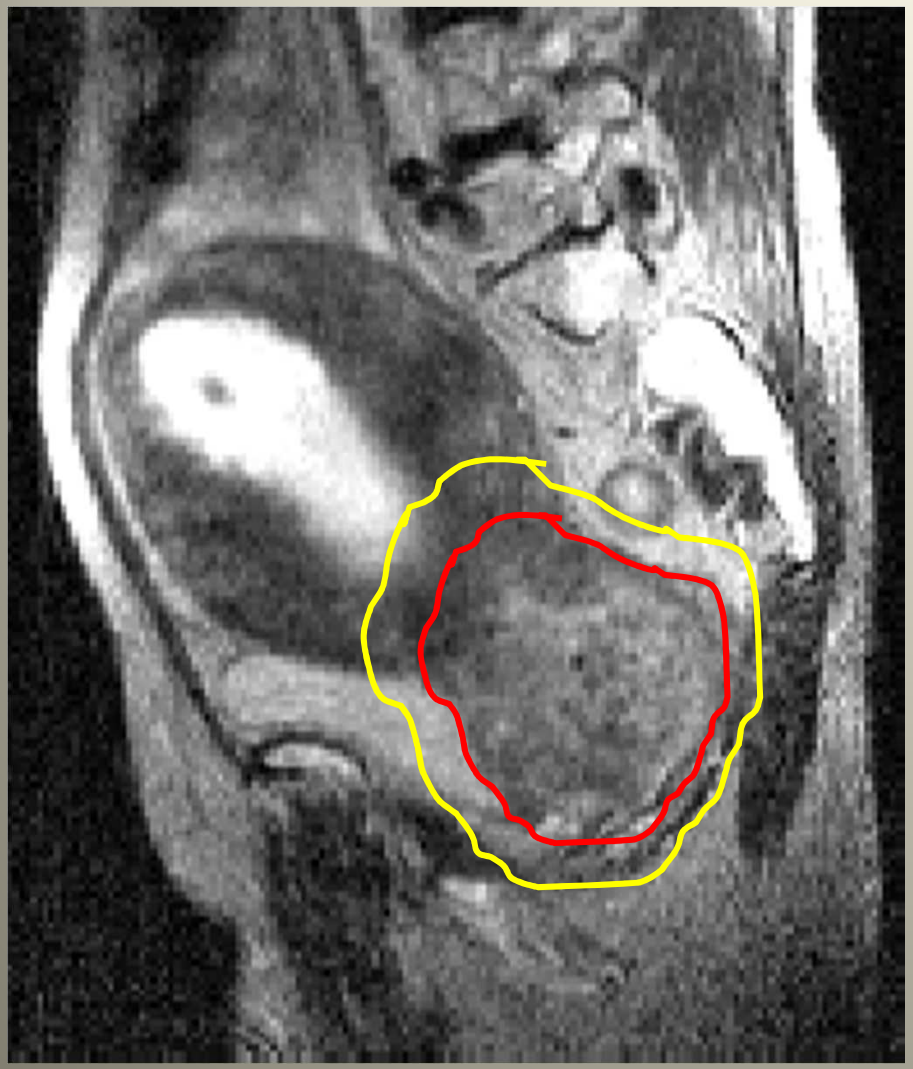
- Tumor load, true pelvis topography and hence CTV for BT (HR and IR CTV) change significantly with time in patients treated with EBRT.
- Systematic description of GTV and CTV in their specific topographic relation at diagnosis and at each time of BT is needed.
- Delineation of GTV and CTV for BT is performed at time of each BT application.

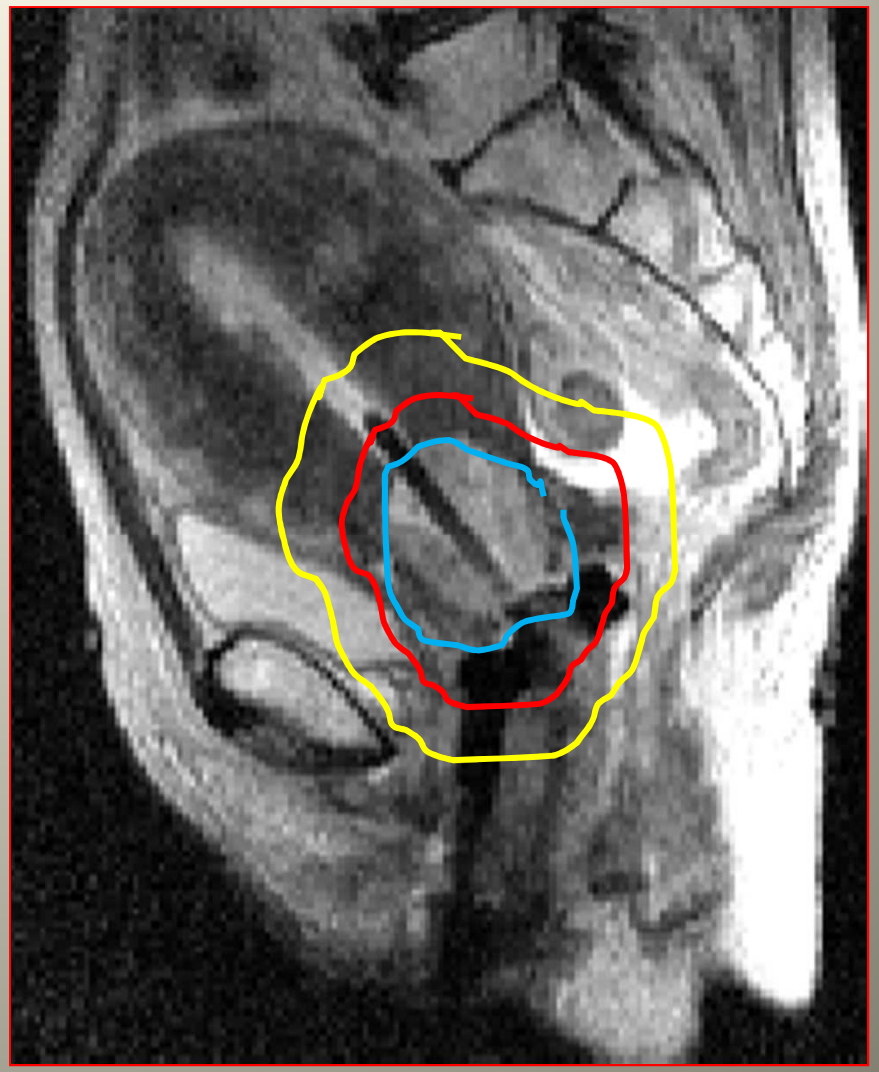
- GTV_B: Macroscopic tumor extension at time of BT as detected by clinical examination or as visualized on MRI on T2 FSE (fast spin echo sequences)

- GTV_D: Macroscopic tumor extension at diagnosis detected by clinical examination or as visualized on MRI on T2 FSE (fast spin echo sequences)

DEFINITION OF CTV

- HR CTV: Includes GTV_B + whole cervix + presumed extracervical tumor extension at the time of BT (GTV_D).
  - No safety margins are added.
  - Total doses appropriate to eradicate macroscopic disease.
  - Doses selected according to tumor volume, stage and treatment strategy.
- IR CTV: Encompasses the HR CTV + 5 to 10mm of safety margin.
  - Significant microscopic tumor load.
  - Safety margin chosen as per tumor size and location, potential tumor spread, tumor regression and treatment strategy.
  - Confined by anatomical borders
  - Total dose appropriate to eradicate significant microscopic disease.





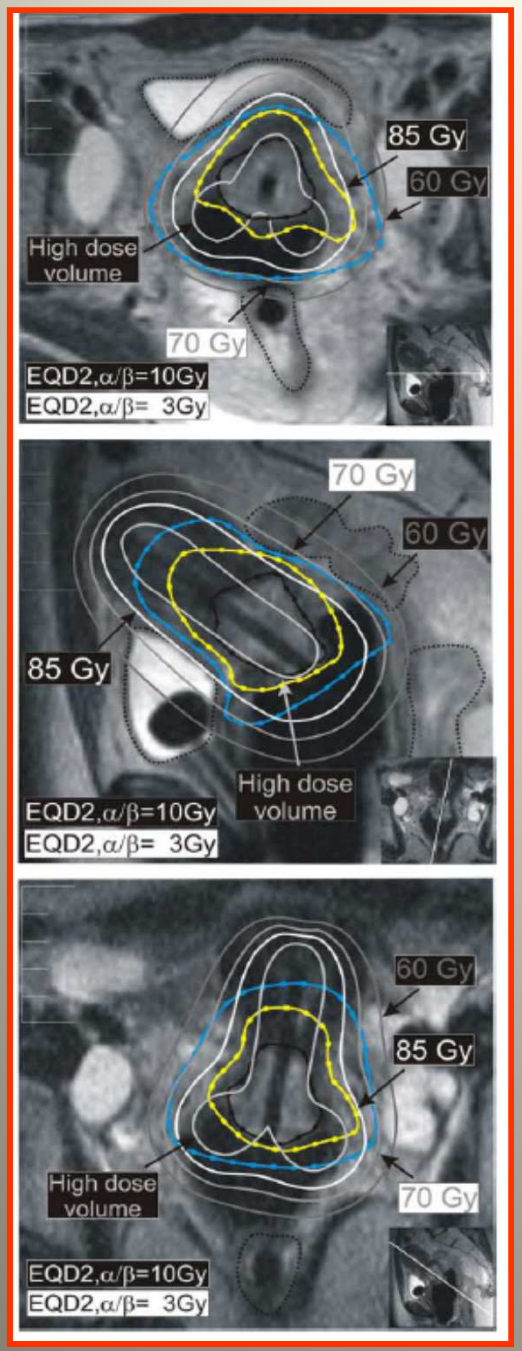
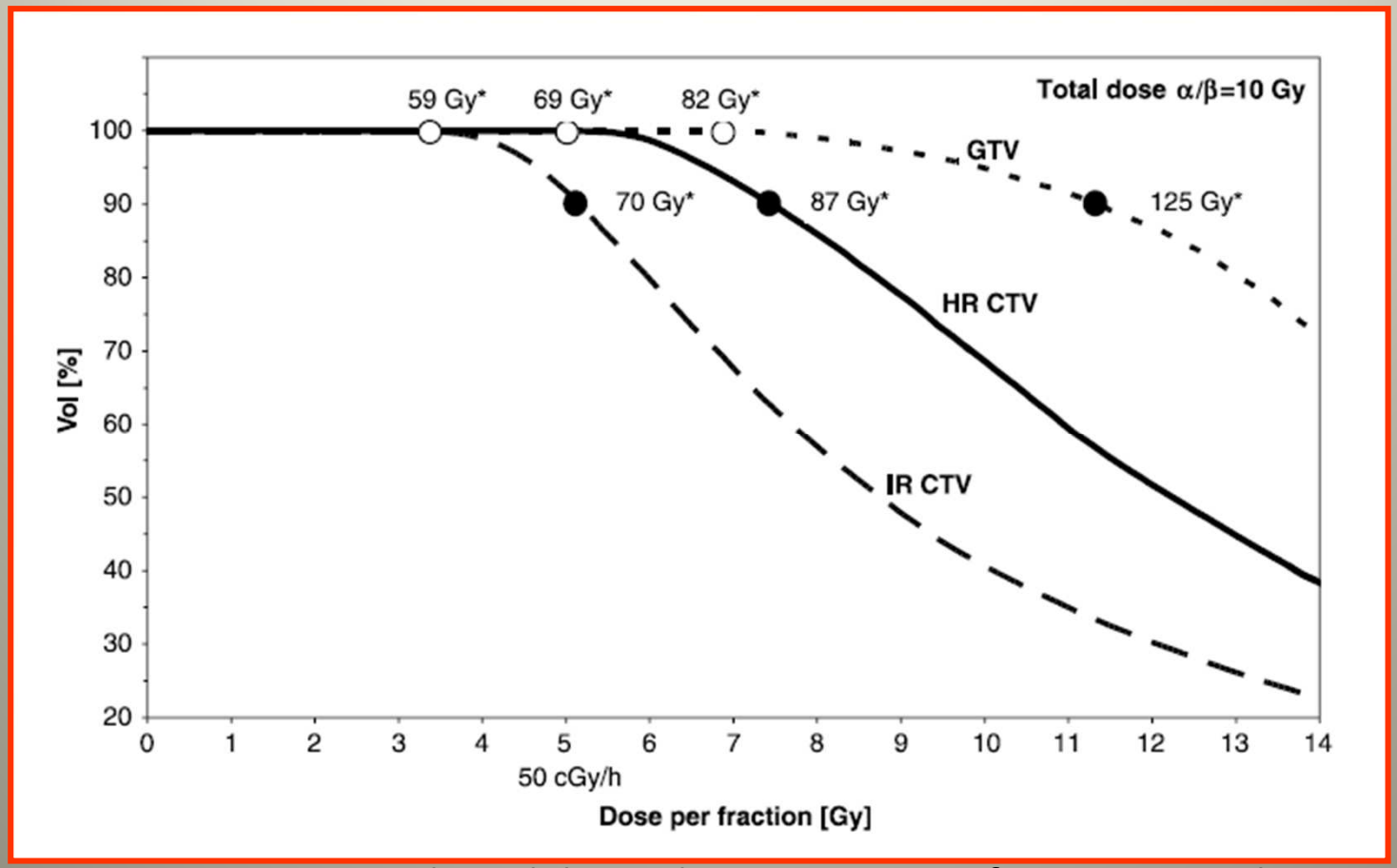


Table 1
Recommendations for recording and reporting 3D gynaecological brachytherapy

Complete description of clinical situation including
anatomy and pathology and imaging examination
dimensions and volume of GTV at diagnosis and at time of brachytherapy
dimensions and volumes of HR CTV and IR CTV, respectively
Complete description of 3D sectional imaging technique and contouring procedure
Complete description of brachytherapy technique
radionuclide; source type (wire, stepping source); source strength; applicator type; type of afterloading (manual or remote); description of additional interstitial needles if any
Treatment prescription and treatment planning
applicator reconstruction technique, standard loading pattern, dose specification method; optimisation method, if applied
Prescribed dose
Total Reference Air Kerma (TRAK)
Dose at point A (right, left, mean)
D100, D90 for GTV and HR CTV and IR CTV, respectively
Dose to bladder and rectum for ICRU reference points
$D_{0.1cc}$, D_{1cc}, D_{2cc} for organs at risk (e.g. rectum, sigmoid, bladder) (vagina[a])
D_{5cc}, D_{10cc} for organs at risk if contouring of organ walls is performed
Complete description of time-dose pattern: physical and
biologically weighted doses ($\alpha/\beta=10$ Gy for GTV and CTV; $\alpha/\beta=3$ Gy for OAR; $T_{1/2}=1.5$ h for GTV, CTV and OAR)

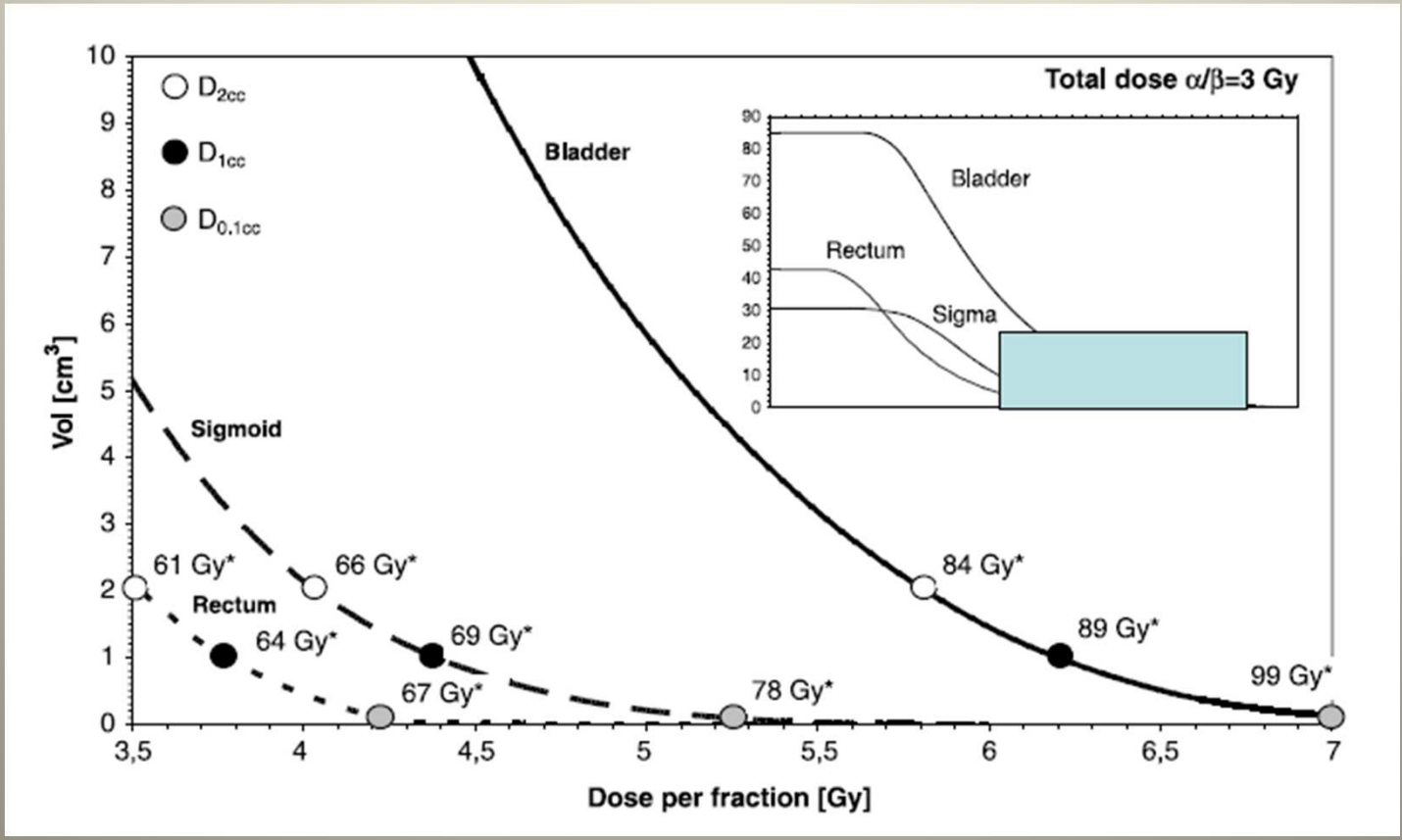
[a] For vagina dose volume parameters still need to be defined.

DVH – TUMOR VOLUMES



- D100, D90 – minimum dose delivered to 100%, 90% of respective volumes, D90 being more stable.
- V(60 Gy_{EQD2}) and V100 – Volume that receive 60 Gy_{EQD2} and 100% of total dose, respectively. V(D Gy_{EQD2}) is preferred for intercomparison purpose

Dose Volume Histogram (DVH) – OAR Volumes



D_{2cc}, D_{1cc}, $D_{0.1cc}$ – minimum dose delivered to 2, 1, and 0.1 cm^3, respectively.

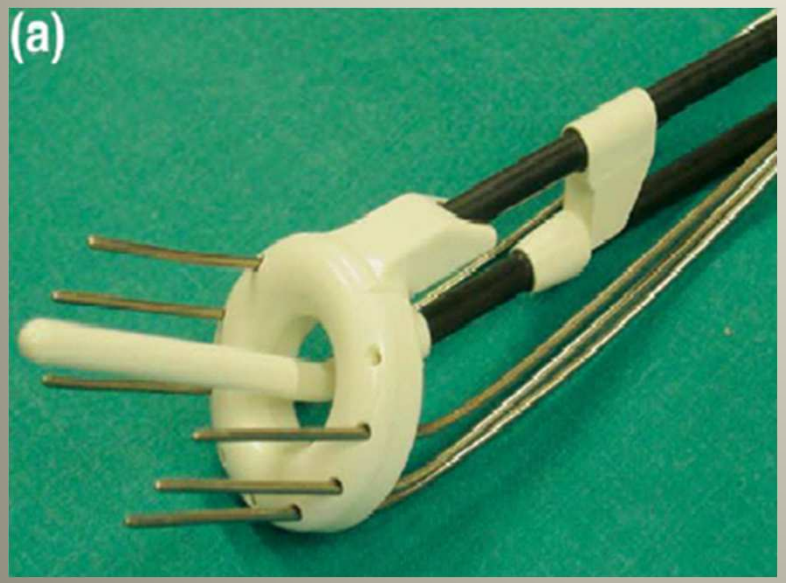
Atypical Applications

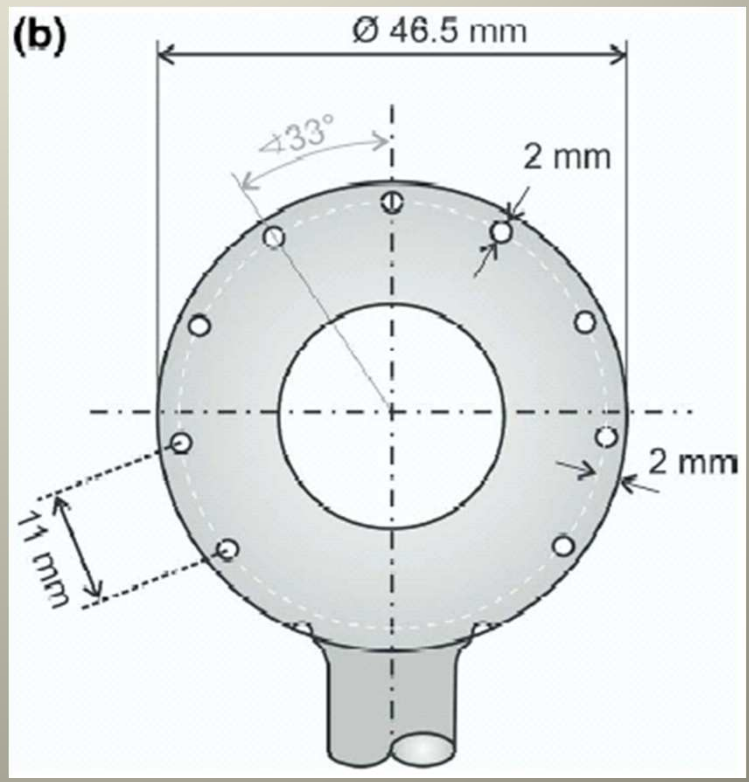
- Single ovoid
- Vienna applicator
- CVS selectron
- Deventer applicator

THE VIENNA APPLICATOR FOR COMBINED INTRACAVITARY AND INTERSTITIAL BRACHYTHERAPY OF CERVICAL CANCER: DESIGN, APPLICATION, TREATMENT PLANNING, AND DOSIMETRIC RESULTS

CHRISTIAN KIRISITS, SC.D., STEFAN LANG, M.SC., JOHANNES DIMOPOULOS, M.D., DANIEL BERGER, M.SC., DIETMAR GEORG, PH.D., AND RICHARD PÖTTER, M.D.

Department of Radiotherapy and Radiobiology, Medical University of Vienna, Vienna, Austria





IJROBP 2006

THE VIENNA APPLICATOR FOR COMBINED INTRACAVITARY AND INTERSTITIAL BRACHYTHERAPY OF CERVICAL CANCER: DESIGN, APPLICATION, TREATMENT PLANNING, AND DOSIMETRIC RESULTS

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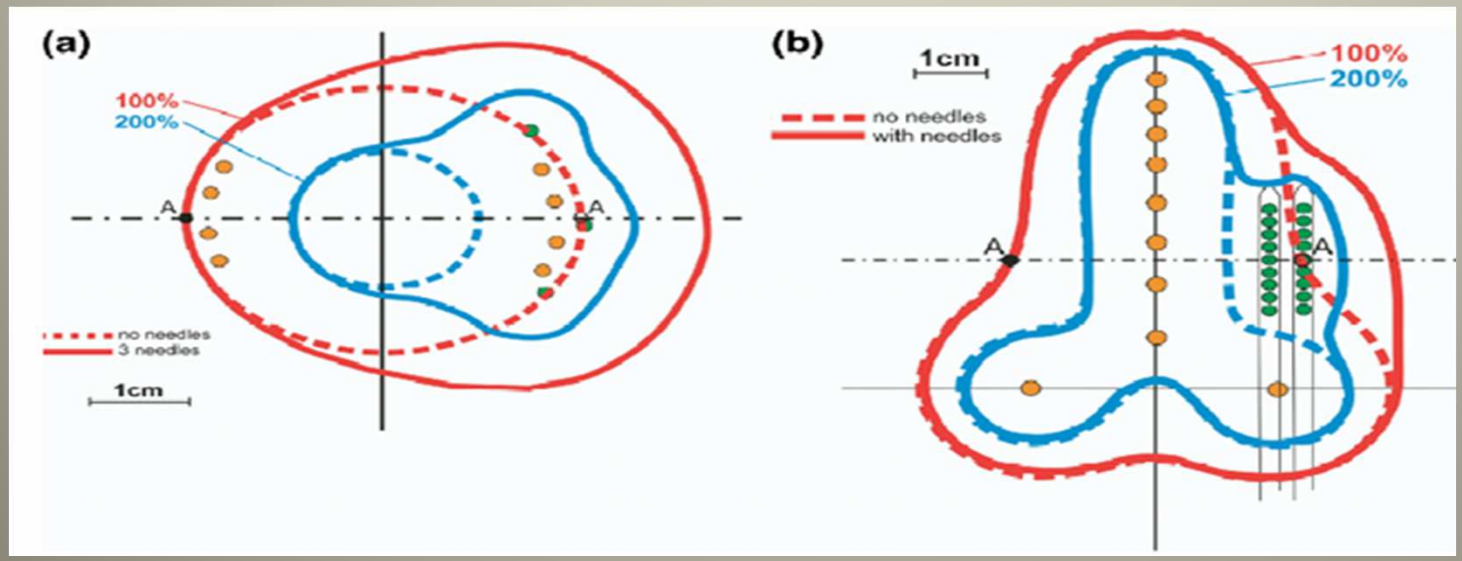

"You can make
a good insertion better
but can't make
a bad insertion good"

THANK YOU