Dose and Volume Specification for Reporting Intracavitary Brachytherapy in Gynecology (Report 38)

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The Presentation..

- Rationale for Brachytherapy
- ICRU 38
- ICRU 89

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Cervical Cancer

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CLINICAL STAGE[b]	BIOPSY RESULTS	PRIMARY TREATMENT (NON-FERTILITY SPARING)	
Stage IA1 no LVSI → Cone biopsy[g]	Negative margins and inoperable	Observe	See Surveillance (CERV-10)
	Negative margins and operable	Extrafascial hysterectomy[i]	See Surveillance (CERV-10)
	Positive margins for dysplasia or carcinoma	Consider repeat cone biopsy[g] to better evaluate depth of invasion to rule out Stage IA2/IB1 disease or Extrafascial or modified radical hysterectomy + pelvic lymph node dissection if margins positive for carcinoma[i] (category 2B for node dissection) (Consider SLN mapping)[i]	See Surgical Findings (CERV-5)
Stage IA1 with LVSI and Stage IA2		Modified radical hysterectomy + pelvic lymph node dissection[i] ± para-aortic lymph node sampling (category 2B) (Consider SLN mapping)[i] or Pelvic EBRT[k,l] + brachytherapy[l,m,n]	See Surgical Findings (CERV-5) See Surveillance (CERV-10)

[b]See Principles of Imaging (CERV-A)

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CLINICAL STAGE[b]	PRIMARY TREATMENT (NON-FERTILITY SPARING)	
Stage IB1 and Stage IIA1	Radical hysterectomy + pelvic lymph node dissection[i] (category 1) ± para-aortic lymph node sampling (category 2B) (Consider SLN mapping)[i,j]	See Surgical Findings (CERV-5)
	or Pelvic EBRT[k,l] + brachytherapy (total point A dose: 80–85 Gy)[l,m] ± concurrent cisplatin-containing chemotherapy[o]	See Surveillance (CERV-10)
Stage IB2 and Stage IIA2 (also see CERV-6 for additional recommendations for non-primary surgery patients)	Definitive pelvic EBRT[l] + concurrent cisplatin-containing chemotherapy[o] + brachytherapy (total point A dose ≥85 Gy)[l,m] (category 1 for primary chemoradiation)	See Surveillance (CERV-10)
	or Radical hysterectomy + pelvic lymph node dissection[i] ± para-aortic lymph node sampling (category 2B)	See Surgical Findings (CERV-5)
	or Pelvic EBRT[l] + concurrent cisplatin-containing chemotherapy[o] + brachytherapy[l,m,p] + adjuvant hysterectomy[q] (category 3)	See Surveillance (CERV-10)

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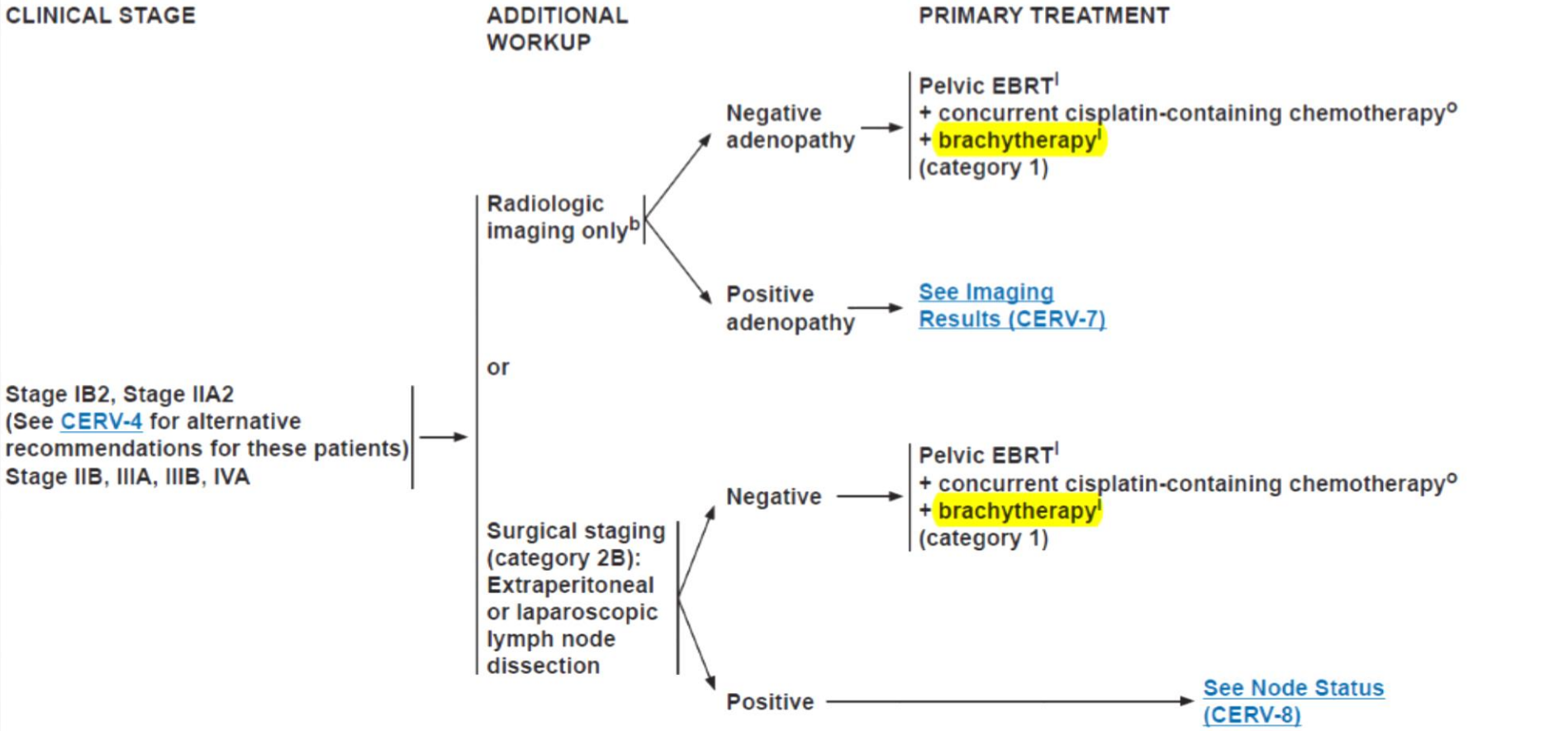

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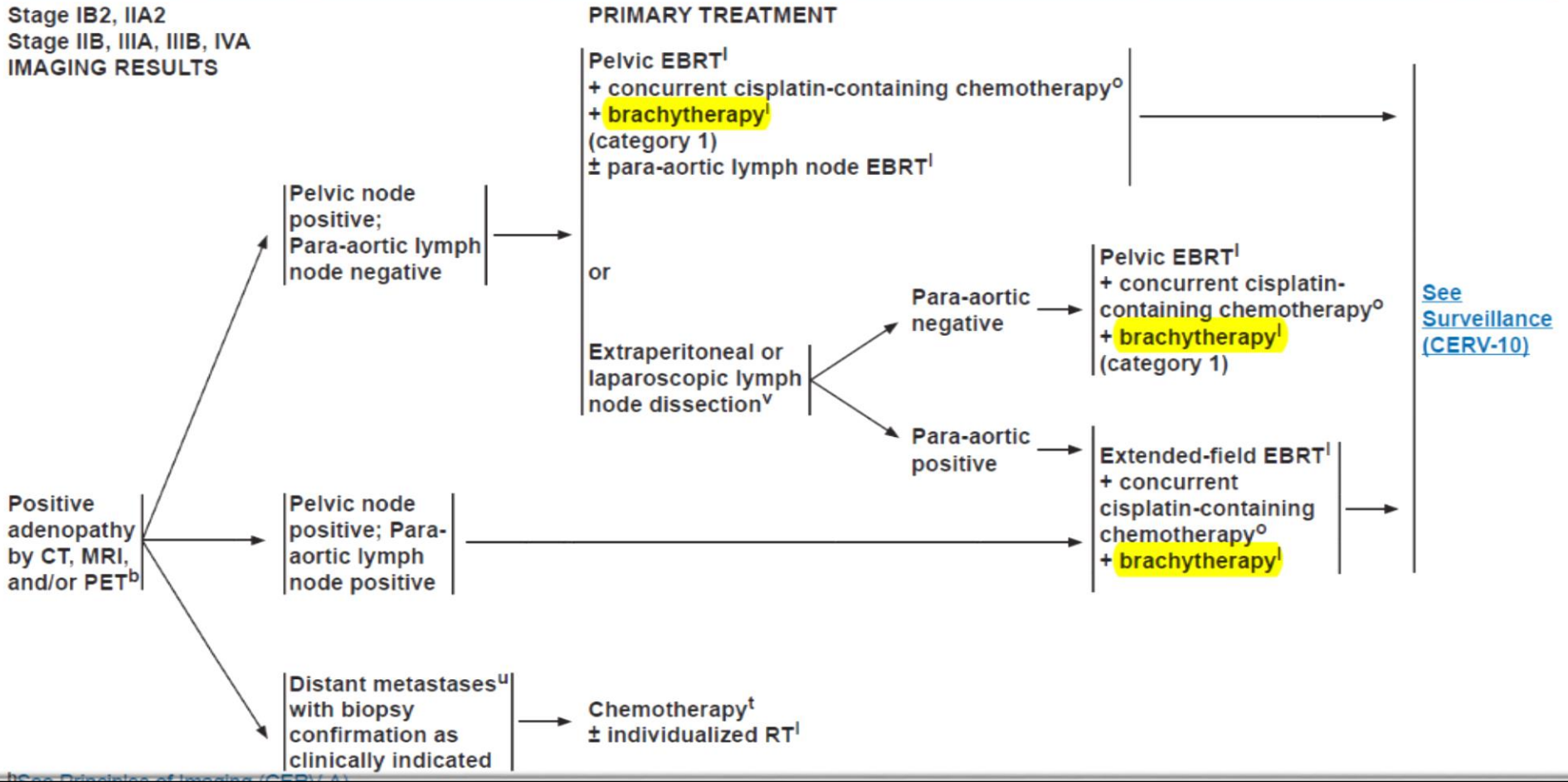


[b]See Principles of Imaging (CERV-A)

Brachytherapy must be included as a component of the definitive radiation for cervical carcinoma.

ABS Recommendations for HDR Brachytherapy in cancer cervix, IJROBP'00(48):201-11

Brachytherapy in Cancer Cervix

Intracavitary

Interstitial

Why we need Brachytherapy

Principles of Rad Onc

Conformal Irradiation

Hypoxic Tm cells

↓

Radioresistant

Adv. of Brachy.

-Highly Localised to Tm vol

-Sharp dose fall-off

-Higher dose at center of vol

-LDR: Reox of hypoxic Tm cells

Why we need Brachytherapy

Cont..

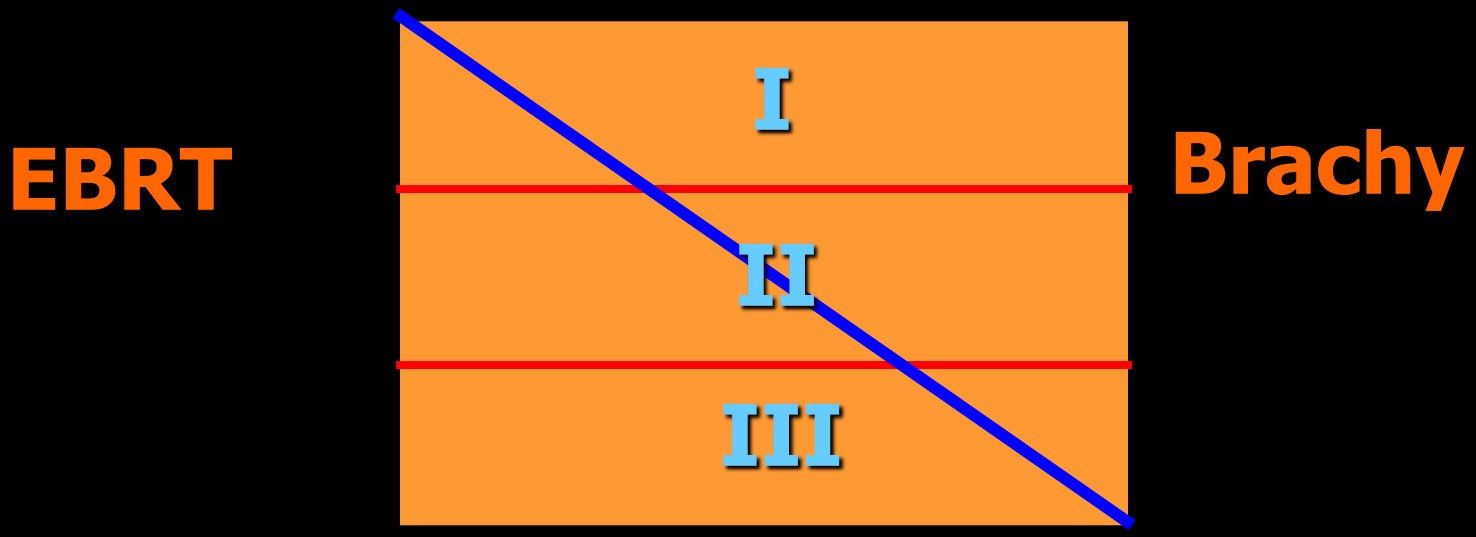
Tissue/organ	Tolerance Dose [TD5/5 whole vol]
Uterus+Cx	100 Gy
Vagina	
Upper	238 Gy
Lower	98 Gy
Rectum	60 Gy
U.B.	65 Gy
Small Int	40 Gy

TARGET

OAR

Emami B,IJROBP'91l;Hintz JL,IJROBP'80;
Hall EJ,5th edn; Grigsby PW,Radiother Oncol'03

EBRT : BRACHYTHERAPY

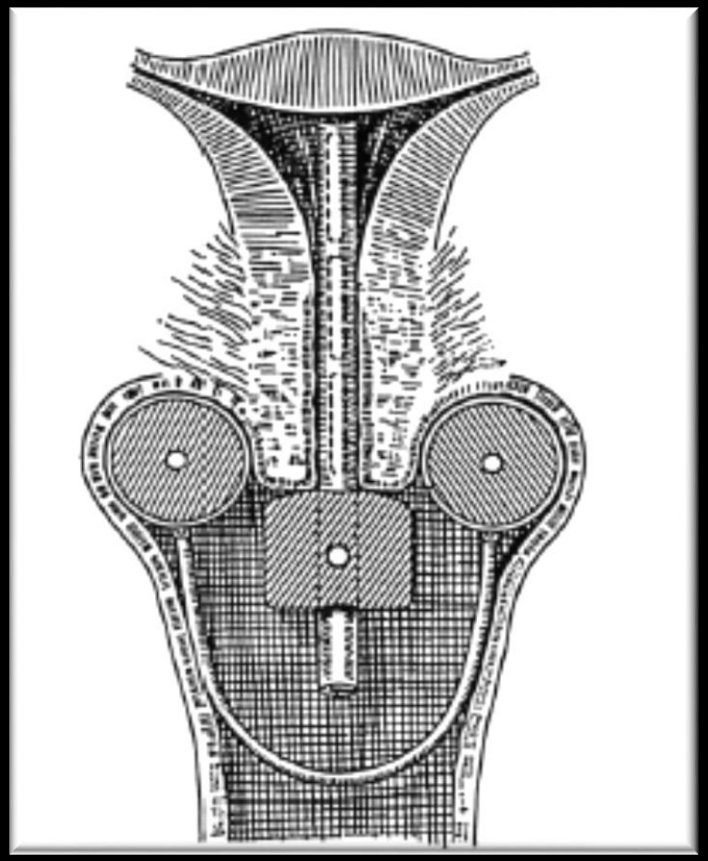


Ratio of EBRT dose to Brachy dose depends on volume & stage of the disease

Dose Specification Systems

Preloaded Radium era **Afterloading era**

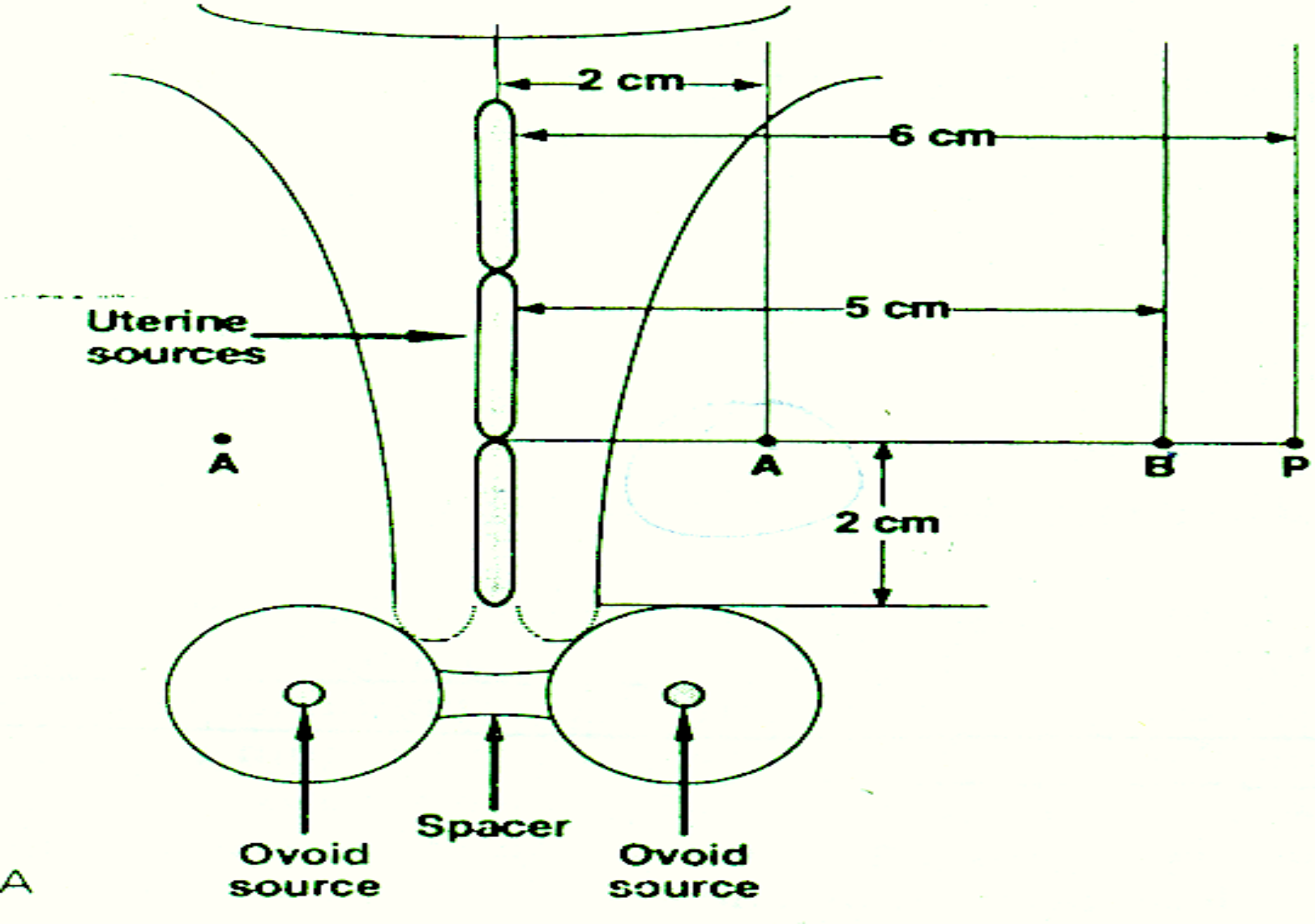
Paris System



Manchester System*[Classical]*

- Ist to use applicators & loadings to satisfy specific dosimetric constraints
- Ist to use Pt A rather than mg-hr to specify treatment

Manchester System *[Classical]*



Manchester System[Classical]

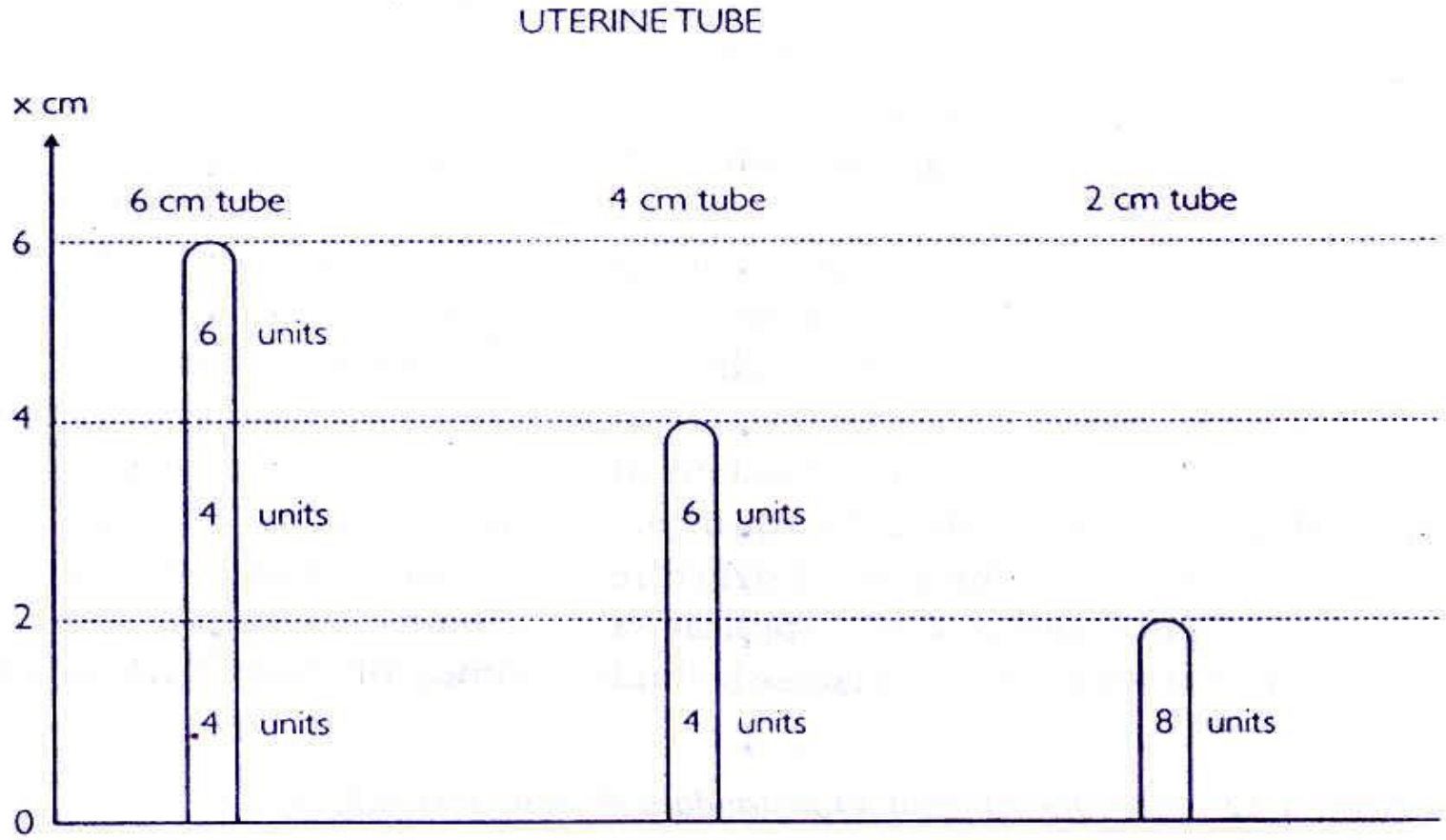
Why Pt A

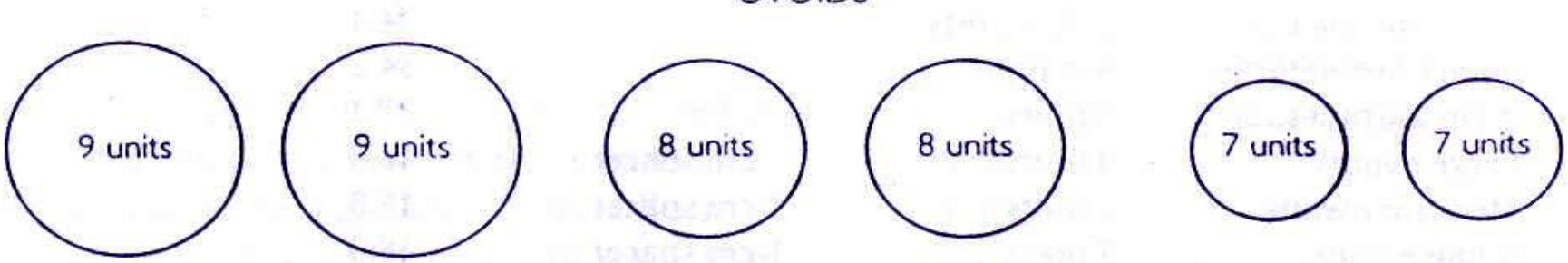
" The radiation necrosis is not the result of direct effects of radiation on bladder & rectum, but high dose effects in the area in medial edge of broad lig where uterine vessels cross ureter"

Meredith WJ, Radiation dosage: Manchester System,1967

Dose rate at this point is not too sensitive to small variation in applicator position

Cont..


UTERINE TUBE
x cm
6 cm tube
4 cm tube
2 cm tube
6
4
2
0
6 units
4 units
4 units
6 units
4 units
8 units


OVOIDS
9 units
9 units
8 units
8 units
7 units
7 units

Limitations of Pt. A

- **Classical Pt A**

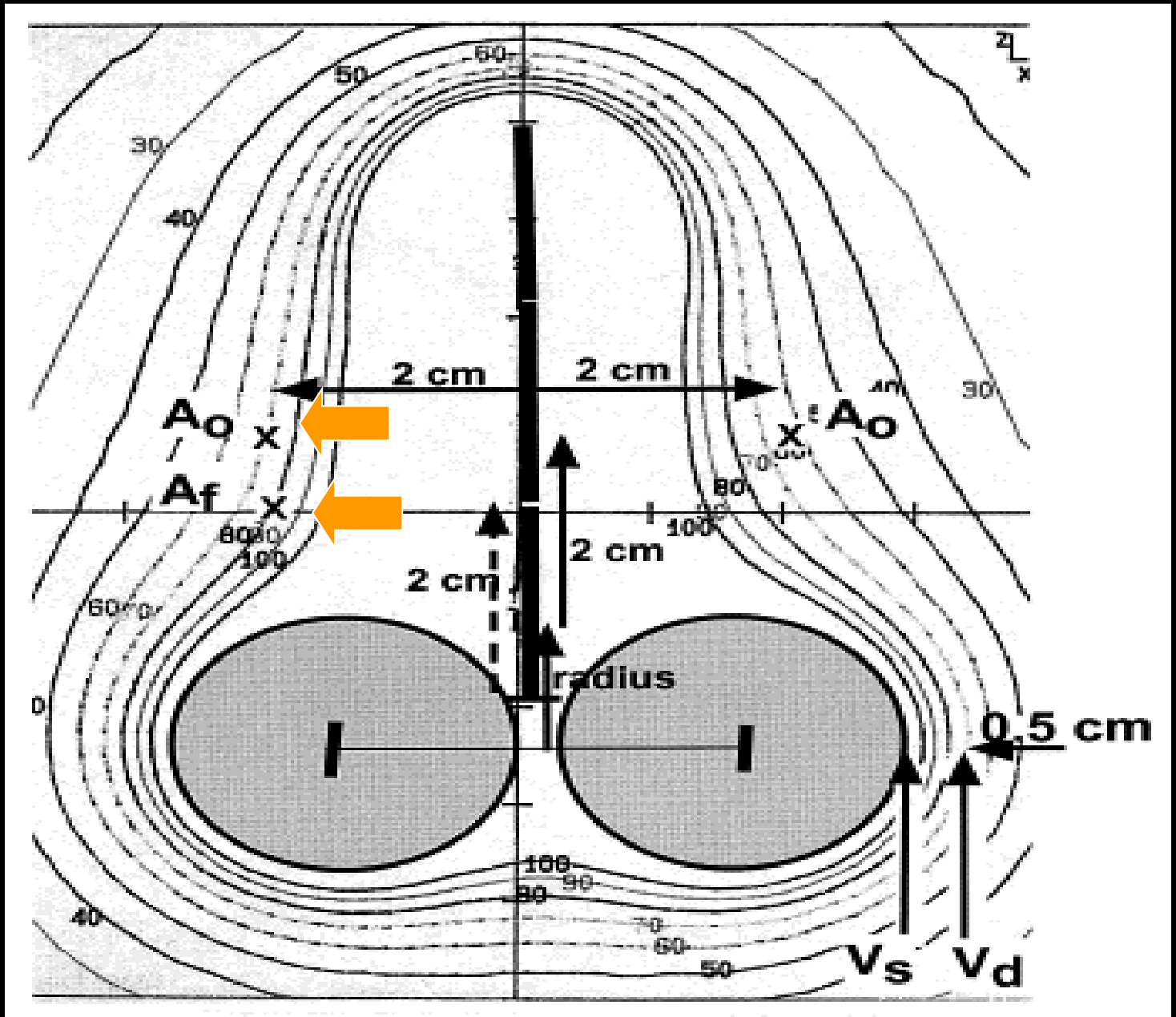
  Difficult to localise surface of ovoids in radiograph

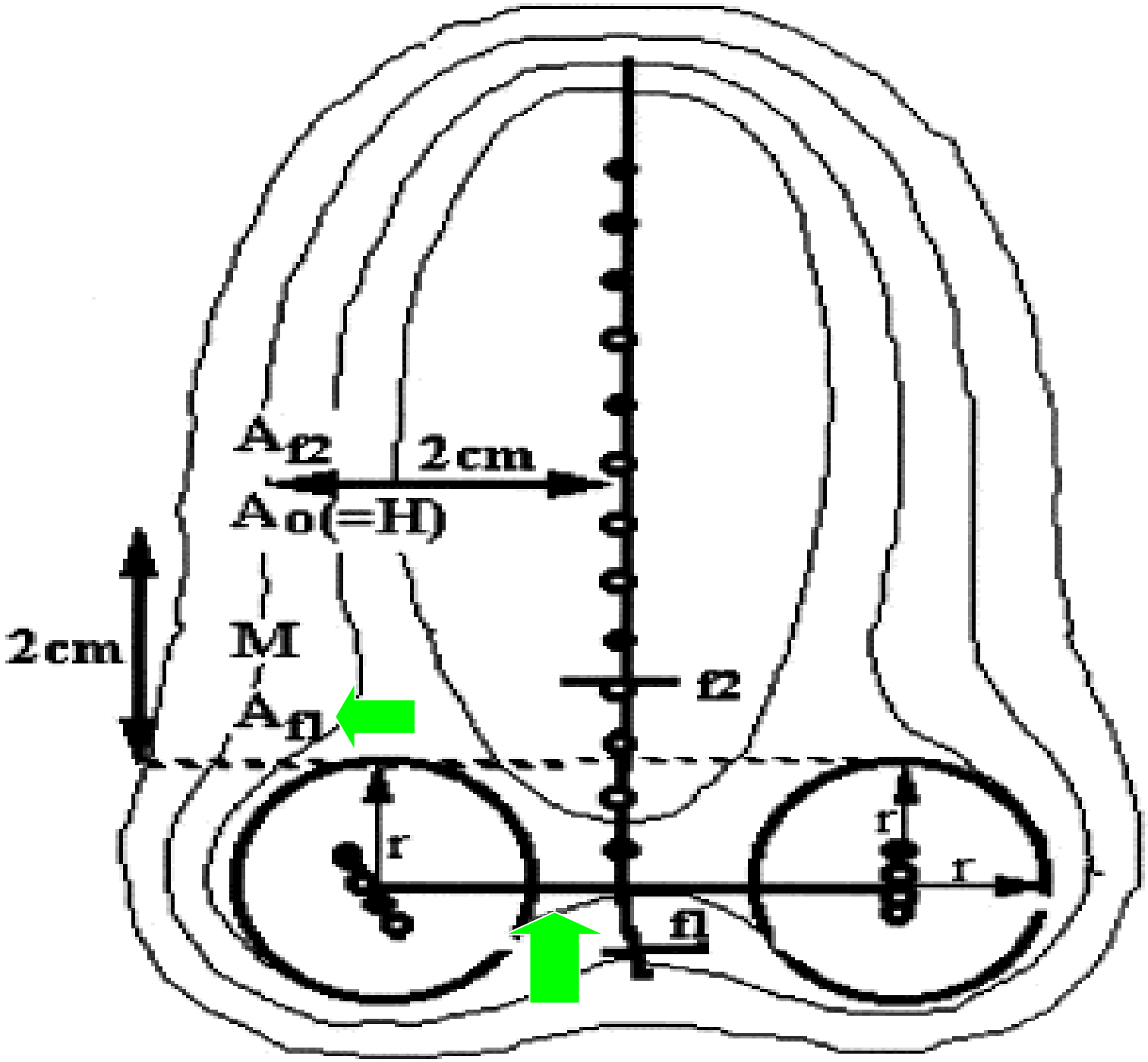
- **Revised Pt A**

  2cm up from lower end of last i.u. source & 2cm lateral in plane of uterus

Limitations of Revised Pt. A

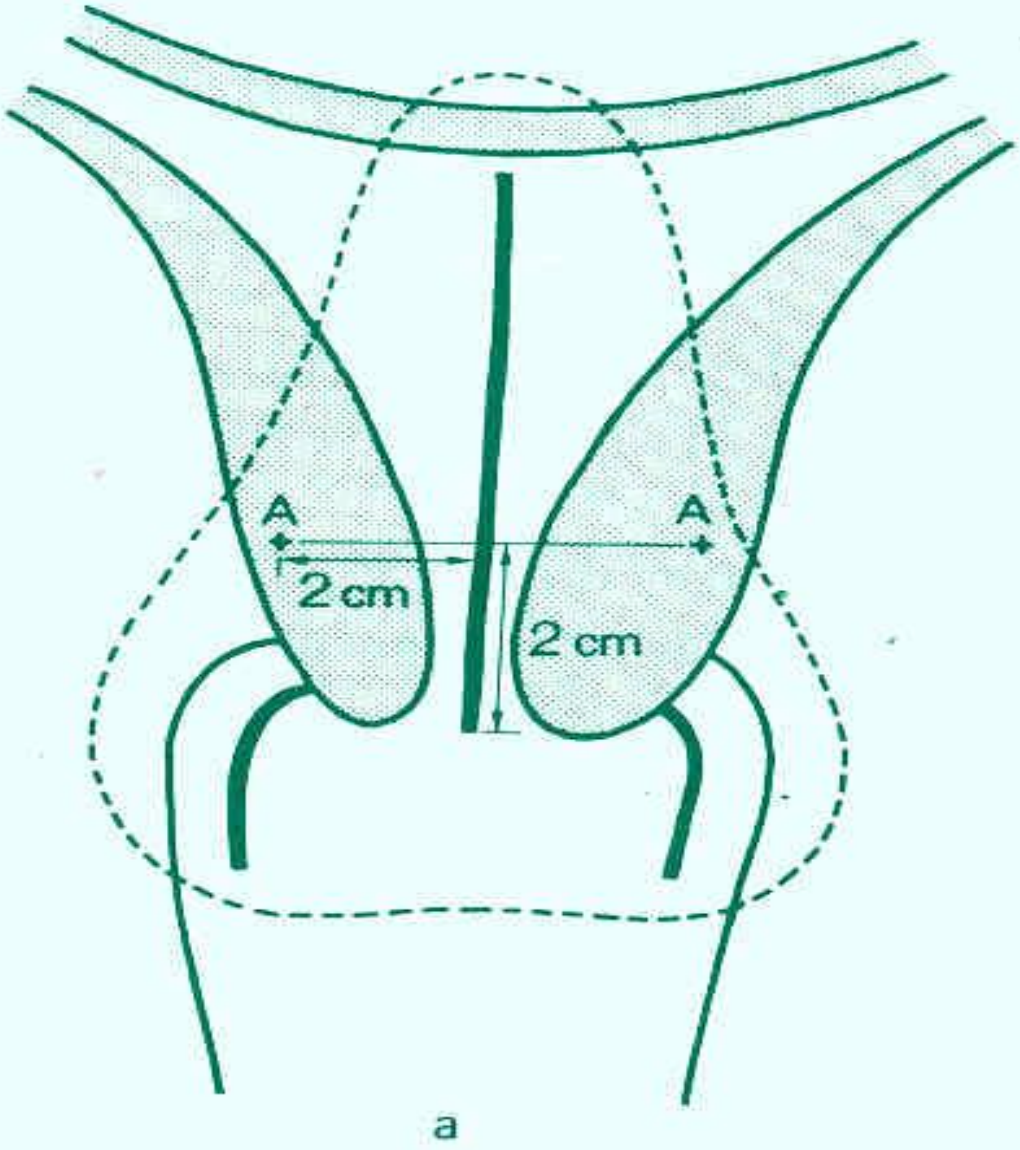
Wide Variation in Rev. Pt A dose wrt ovoids:

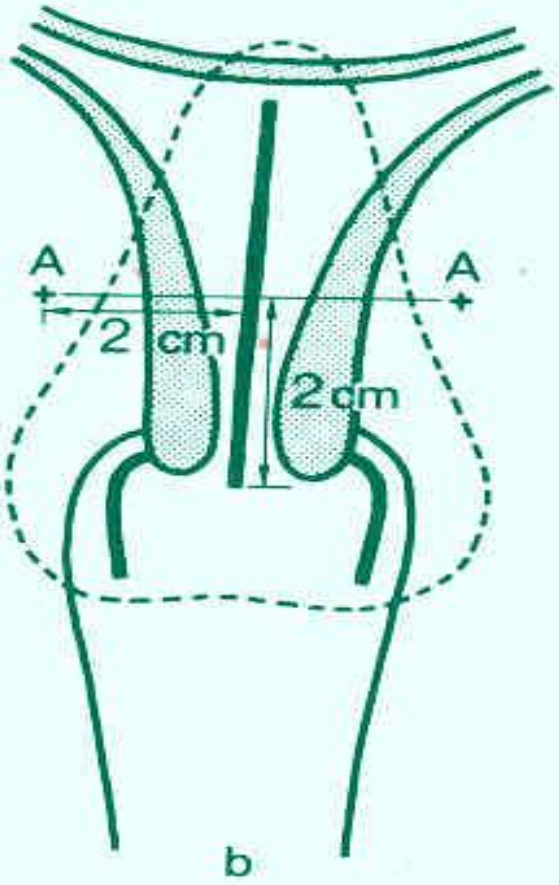



A f2
2 cm
A o(=H)
2 cm
M
A f1
f2
f1
r
r
r

Limitations of Revised Pt. A

Dependence on size of cervix:





Dose &Volume Specification for Reporting ICRT

[ICRU Report 38]

Reasons

- Ra being replaced by Cs137, Ir192
- Old systems unsuitable for new sets of sources available
- SI units, now being widely used
- Use of computers for calculation & dose distribution

1985: ICRU Report 38

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

ICRU-38 Reporting

- Description of the technique used
- Total reference air kerma (cGy @ 1m)
- Reference volume
  - Usually at isodose with D_{total} of 60Gy, must specify otherwise
    - $D_{total} = D_{EBRT} + D_{BT}$
  - Shape (pear) and dimensions
- Absorbed dose at reference points
  - Bladder
  - Rectum
  - Lymphatic trapezoid
  - Pelvic wall reference point
- Time dose pattern

Total Reference Air Kerma (TRAK)

$$TRAK = \Sigma S_i . t_i$$

Where;

S_i = Reference air kerma rate for each source.

t_i = Irradiation time for each source.

- **This quantity is analogous to mg.h**

ICRU Report 38:Recommendations for Reporting

An absorbed dose level of 60 Gy is accepted as the appropriate reference level for conventional LDR therapy reporting.

When 2 or more IC applications are performed, the absorbed dose to consider is that resulting from all applications.

When ICRT is combined with EBRT, the isodose level to be considered is the difference between 60 Gy & the dose delivered at same location by EBRT.

For ICRT at MDR/HDR, the rad onc has to indicate the dose level which he/she believes to be equivalent to 60 Gy delivered at LDR.

VOLUMES FOR REPORTING

Treatment Volume

It is the volume that received (at least) the dose selected and specified by the radiation oncologist as being appropriate to achieve the purpose of the treatment

Reference volume

The reference volume is the volume encompassed by the reference isodose, selected and specified to compare performed in different centres using different technique

Irradiated volume

- The volumes surrounding the Treatment Volume, encompassed by a lower isodose to be specified
  - e.g. 50% of the dose defining the TV

- Reporting irradiated volumes may be useful for interpretation of side effects outside the TV

Why Reference Volume?

- In EBRT, selection of the “reference point for reporting” in the centre of the PTV
- But not in intracavitary brachytherapy due to the steep dose gradient especially in the vicinity of the radioactive sources
- Instead of reporting the dose at a point, the dimensions of the volume included in the corresponding isodose reported

Reference Volume

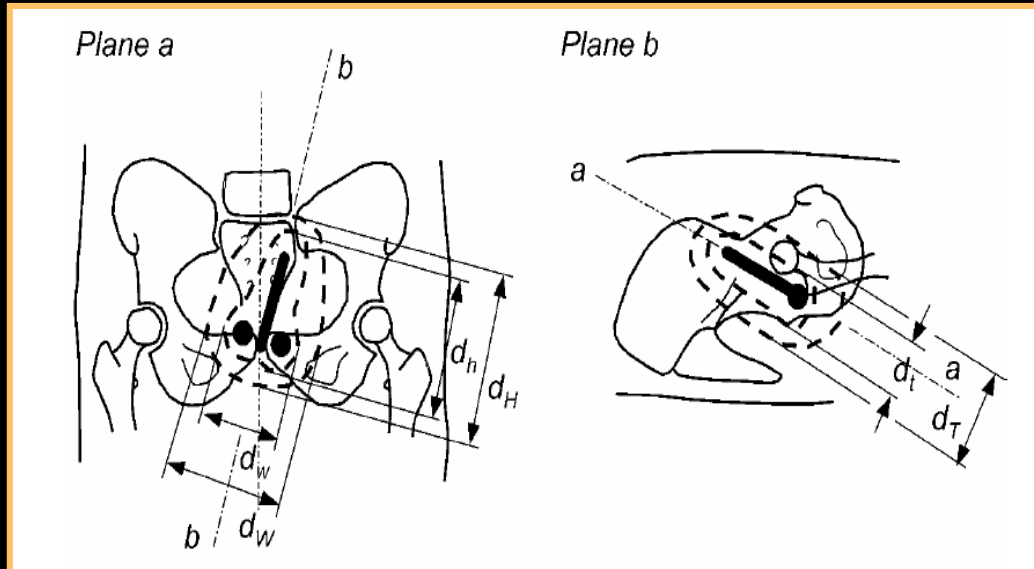
Pear-shape…longest axis coincident with intrauterine source

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***

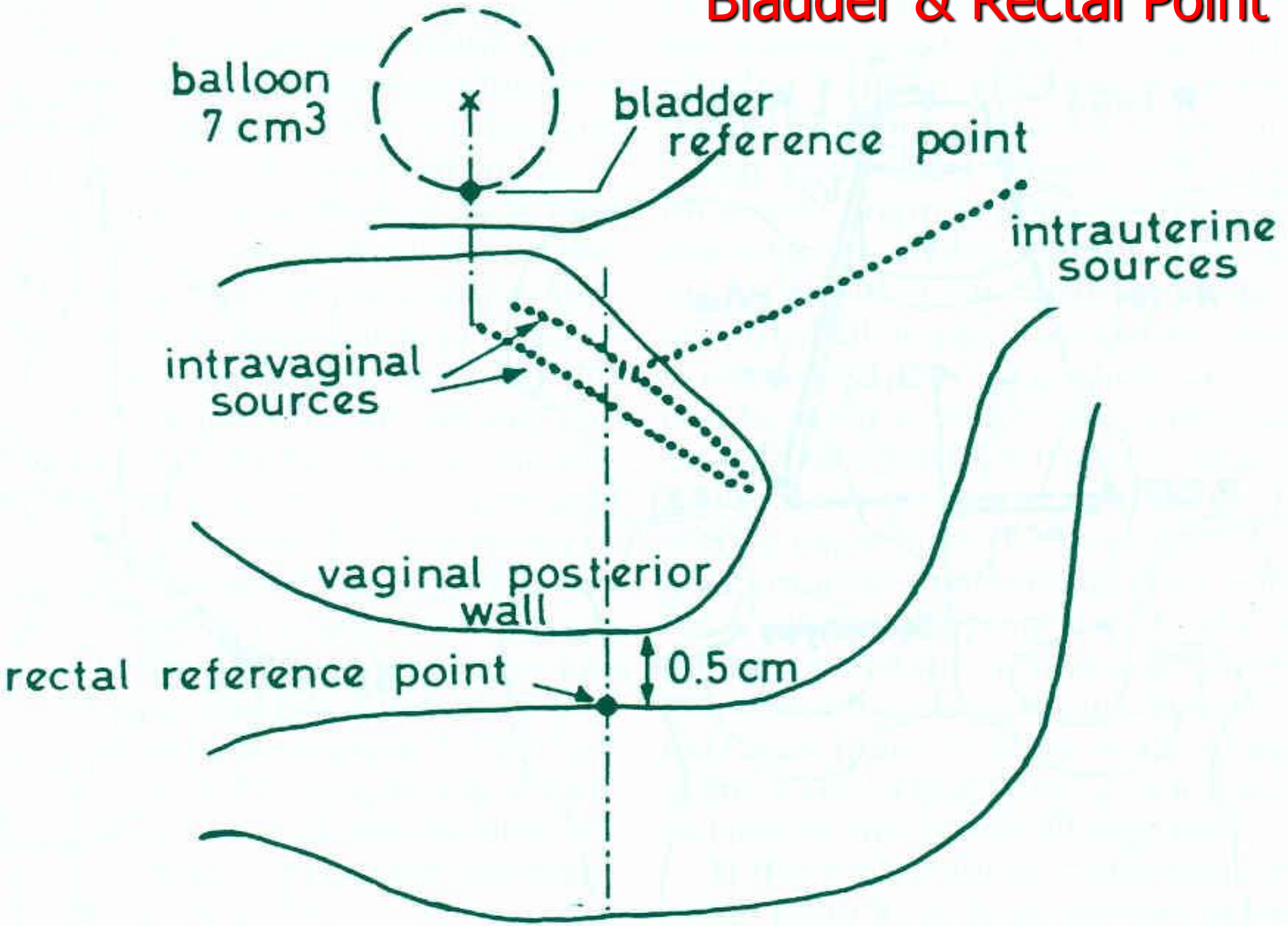
Thickness (d*t*) - ***maximum dimension perpendicular to intrauterine source measured in Oblique saggital plane***

These dimensions are usually expressed in cm

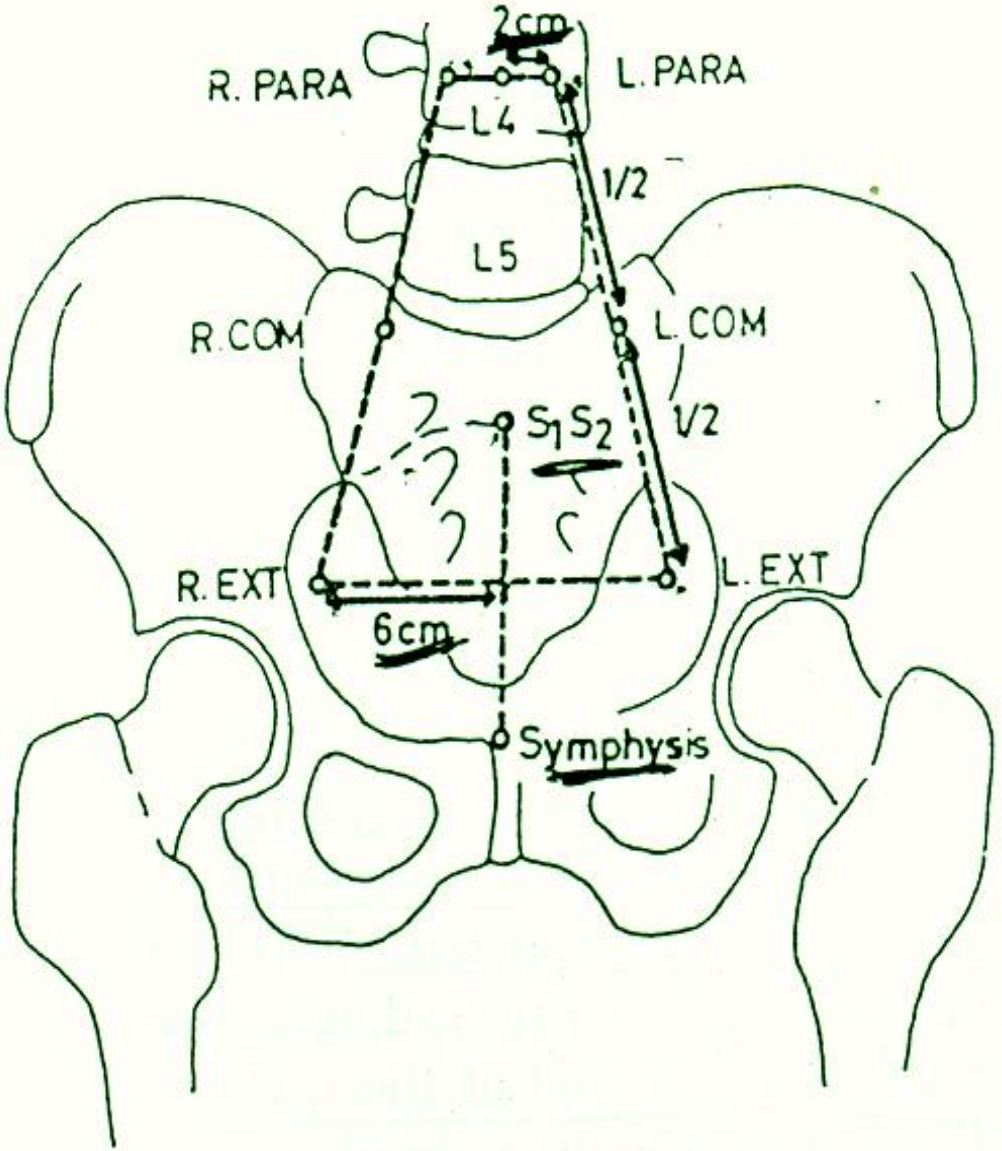


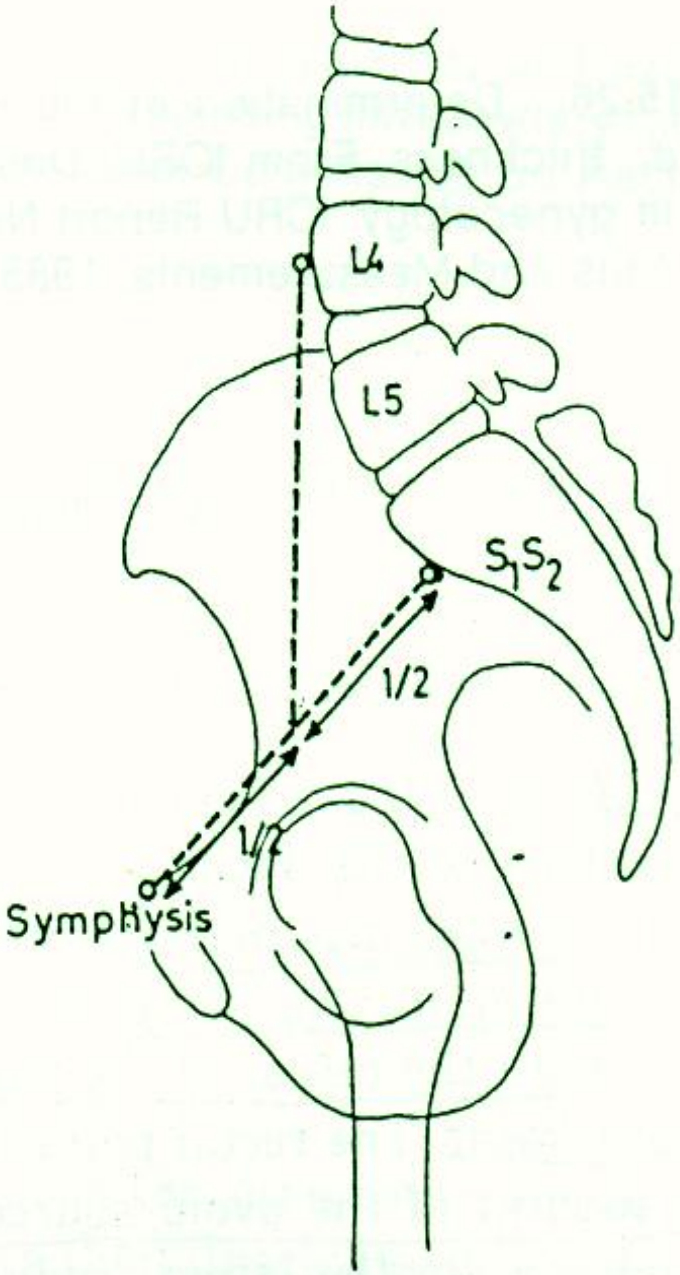
Absorbed Dose at Reference Points

Bladder & Rectal Point

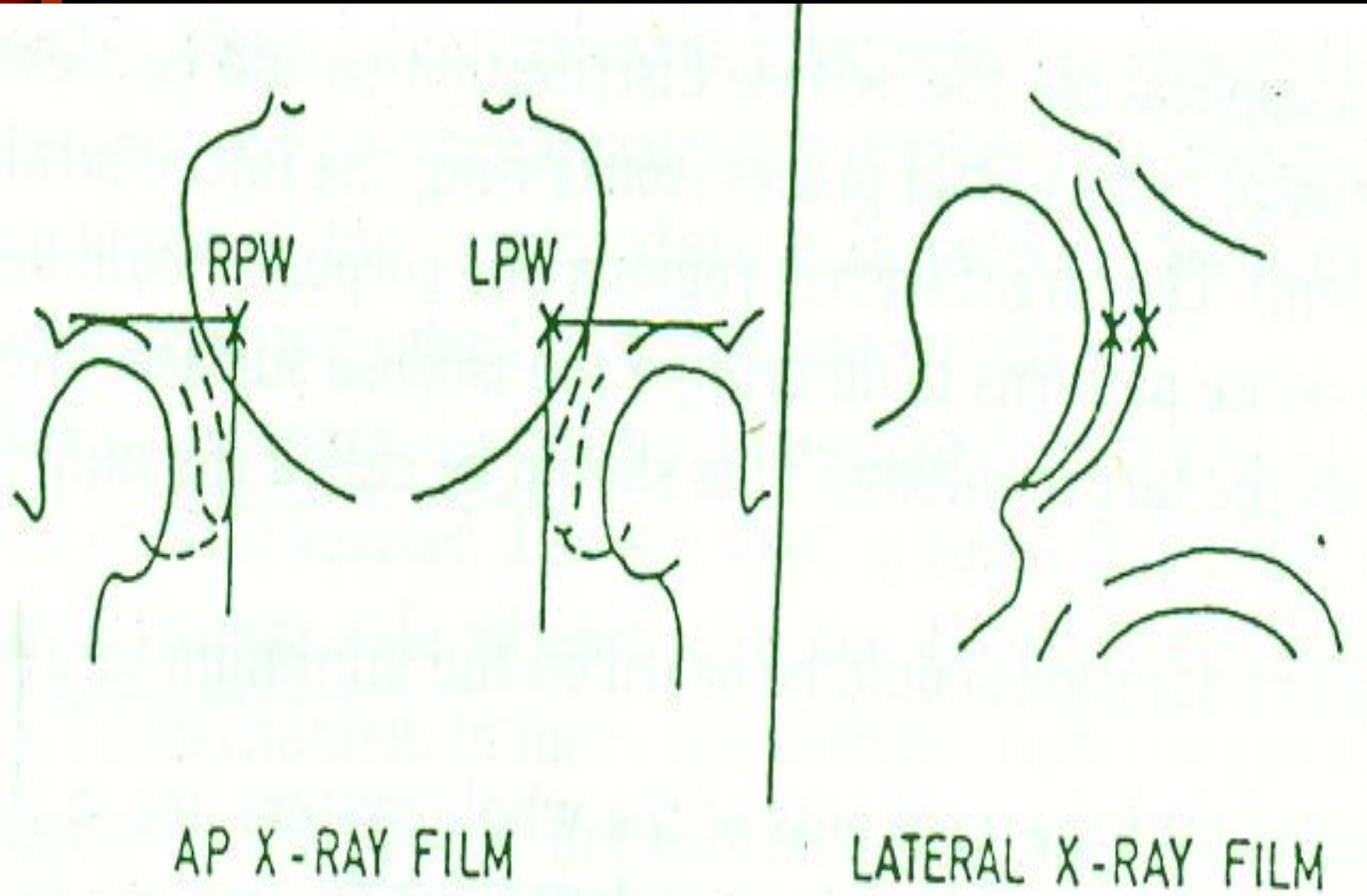


Fletcher Lymphatic Trapezoid Points



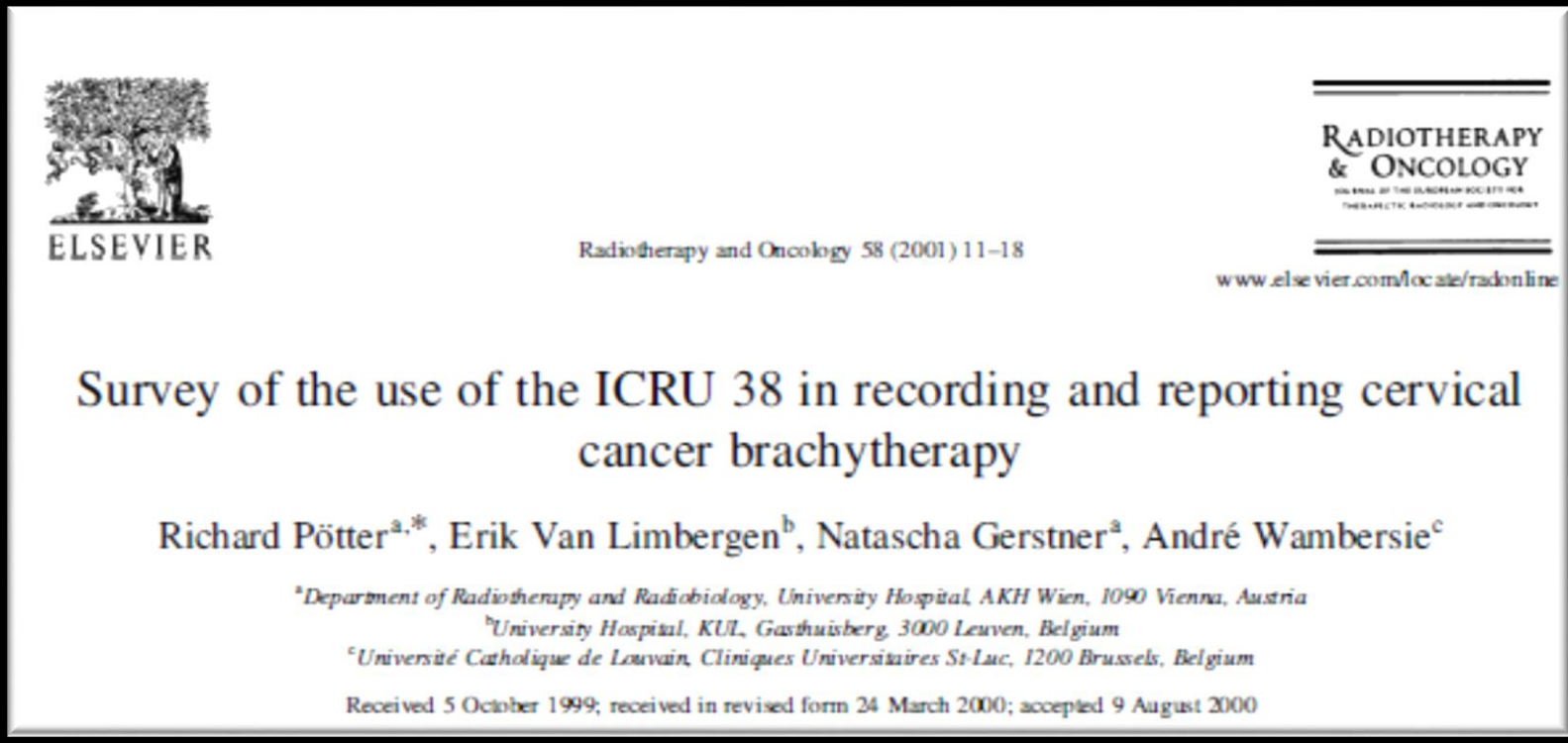


Pelvic Wall Points



ICRU 38: *Criticism*

- No guidance for dose prescription
- How to correlate reference volume dimensions with clinical outcome ?
- No explanation for selecting 60 Gy as ref isodose level
- Whether absorbed dose at reference points accurately indicates the absorbed dose in volume of interest?



ELSEVIER

Radiotherapy and Oncology 58 (2001) 11–18

RADIOTHERAPY & ONCOLOGY

www.elsevier.com/locate/radonline

Survey of the use of the ICRU 38 in recording and reporting cervical cancer brachytherapy

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Received 5 October 1999; received in revised form 24 March 2000; accepted 9 August 2000

- **Questionnaires sent to all ESTRO members (1600 institutions)**
- **85 institutions answered**

Cont..

Survey on the practice of reporting in cervix cancer brachytherapy[7]

Parameter reported in %	Questionnaire		Literature	
	LDR ($n = 37$)	HDR ($n = 29$)	LDR ($n = 78$)	HDR ($n = 50$)
Technique				
Machine type/source	78	100	69	84
Applicator type	97	100	74	62
Amount of radiation				
TRAK (in Gy)	43	14	10	0
Milligram hour of radium (in mg h)	–	–	38	0
Dose specification to the target volume				
60 Gy reference volume	51	18	17	0
Dose to Point A	76	89	60	96
Dose to Point B	62	65	18	16
Dose to other reference points	–	–	6	0
Dose specification to the organs at risk and other points				
ICRU bladder point	84	58	29	14
ICRU rectum point	90	55	18	28
Other bladder points	27	17	6	4
Other rectum points	32	21	24	6
ICRU pelvic wall point	43	38	10	4
Lymphatic trapezoid	35	21	9	0
Other points (PW, LN, Va.)	–	–	18	0
In vivo dosimetry				
Bladder	5	24	4	16
Rectum	13	41	6	22
Time–dose pattern				
Dose per fraction	89	93	82	98
Number of fractions	86	100	97	96
Total brachytherapy dose	92	96	86	100
Dose rate	–	–	37	10
Overall treatment time	86	79	44	30

ICRU REPORT No. 89

PRESCRIBING, RECORDING, AND REPORTING BRACHYTHERAPY FOR CANCER OF THE CERVIX

THE INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS
PREPARED IN COLLABORATION WITH
Groupe Européen de Curiethérapie –
European Society for Radiotherapy and Oncology (GEC-ESTRO)
(Published June 2016)

MR Image Based Brachytherapy Workflow

- **Pre Rx** : Clinical examination / drawings / MR at diagnosis
- **Brachytherapy** : EUA, Appropriate Applicator placement
- **MR Imaging** : Bladder protocol, T2 axial, sagittal, coronal (3-5mm with 1mm)

Standardized protocol (GEC-ESTRO RECOMMENDATION-IV)

- **Contouring** : Targets (GTV-B, HR-CTV, IR-CTV & OAR's (Rect, Blad, Sigm, SB)

(GEC-ESTRO RECOMMENDATION-I)

- **Planning** : TPS

  Catheter reconstruction *(GEC-ESTRO RECOMMENDATION-III)*

  - Loading pattern (Std with Needles loading < 15% only)
  - Optimization (Manual / Inverse)

- **Plan evaluation**: EQD2 values *(GEC-ESTRO RECOMMENDATION-II)*

  - Doses to HR-CTV, GTV (D90, D100, V100 etc…)
  - Doses to OAR's (rectum, bladder, sigmoid 0.1 cc, 1 cc, 2cc)

GTV assessment and CTV definition Gyn BT: where does it come from?

- **High Risk Target Volume (HR CTV)** (Dose 75-80-90+ Gy)

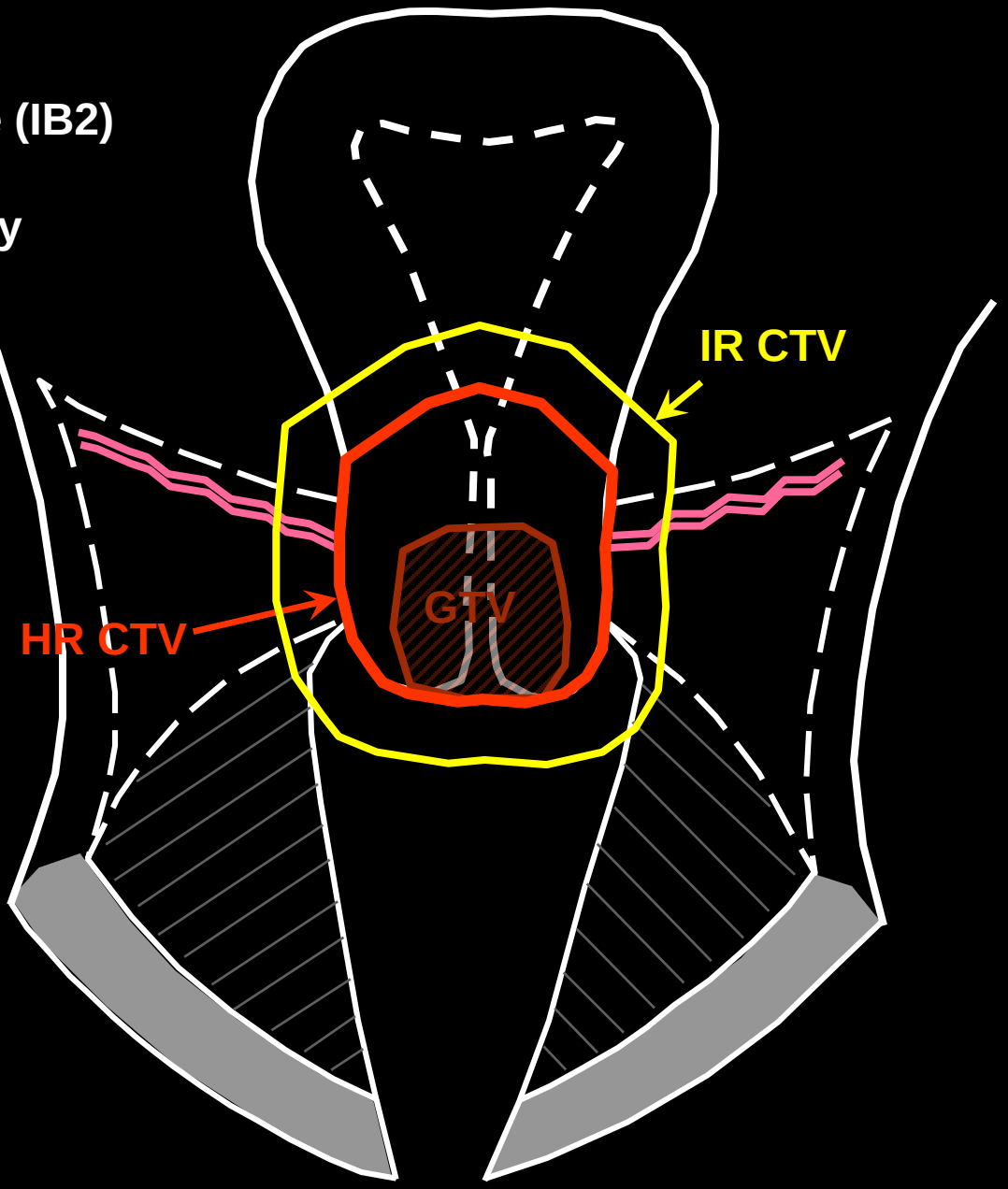
  Macroscopic tumour/cervix at BT
  Whole Cervix
  Residual pathology in parametria
  Residual pathology in vagina, uterine corpus

- **Intermediate Risk Target Volume (IR CTV)** (Dose ~ 60 Gy)

  macroscopic tumour at diagnosis superimposed
  on anatomy at time of brachytherapy + safety margins
  towards parametria, vagina, uterine corpus

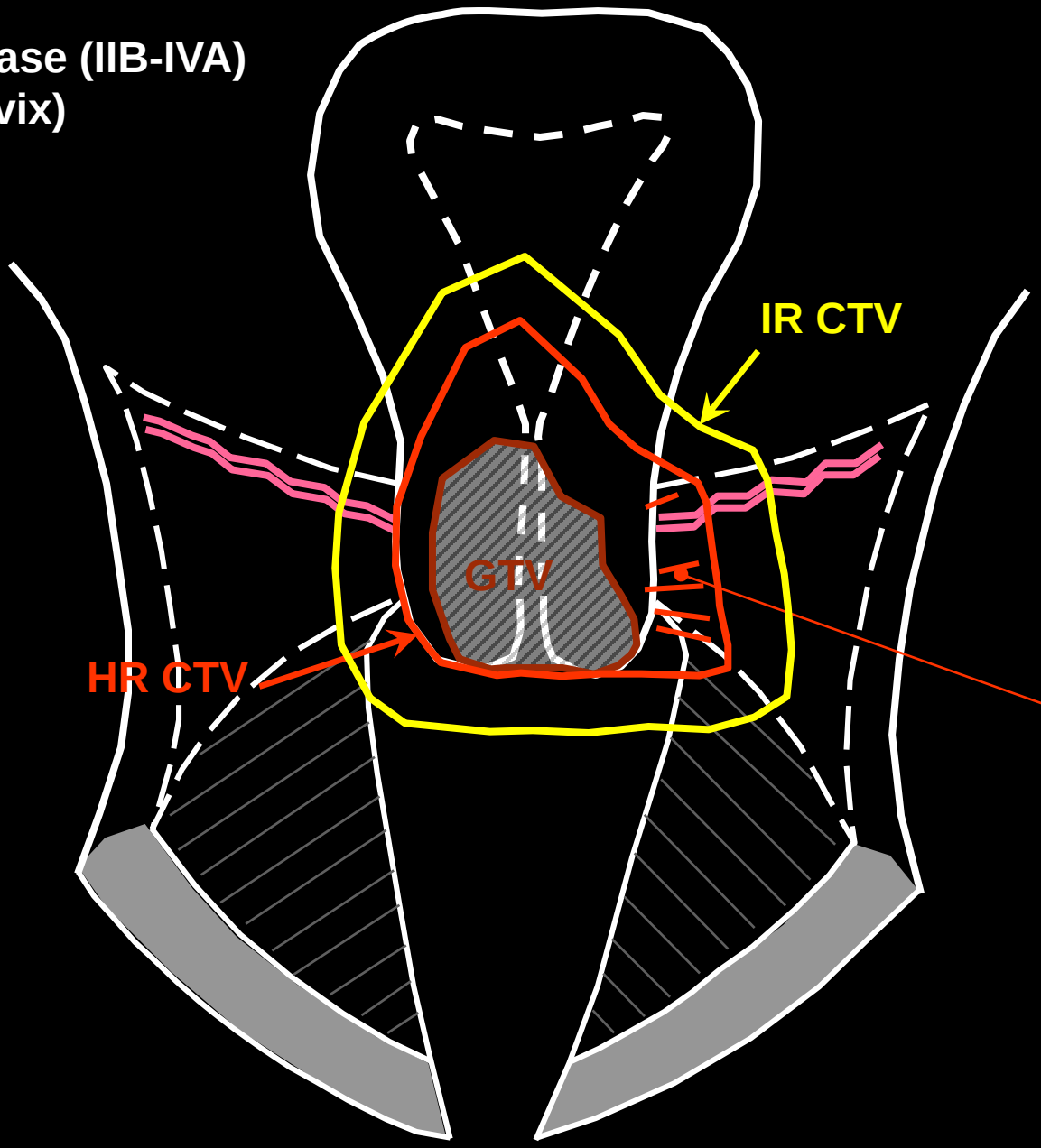
GYN GEC ESTRO; Recommendations(I); R&O 2005

Limited Disease (I)
Extensive Disease (IB2)
at diagnosis
at brachytherapy
(Intact Cervix)



GYN GEC ESTRO Recommendations (I) Radioth.Oncol. 2005, 74:235-245

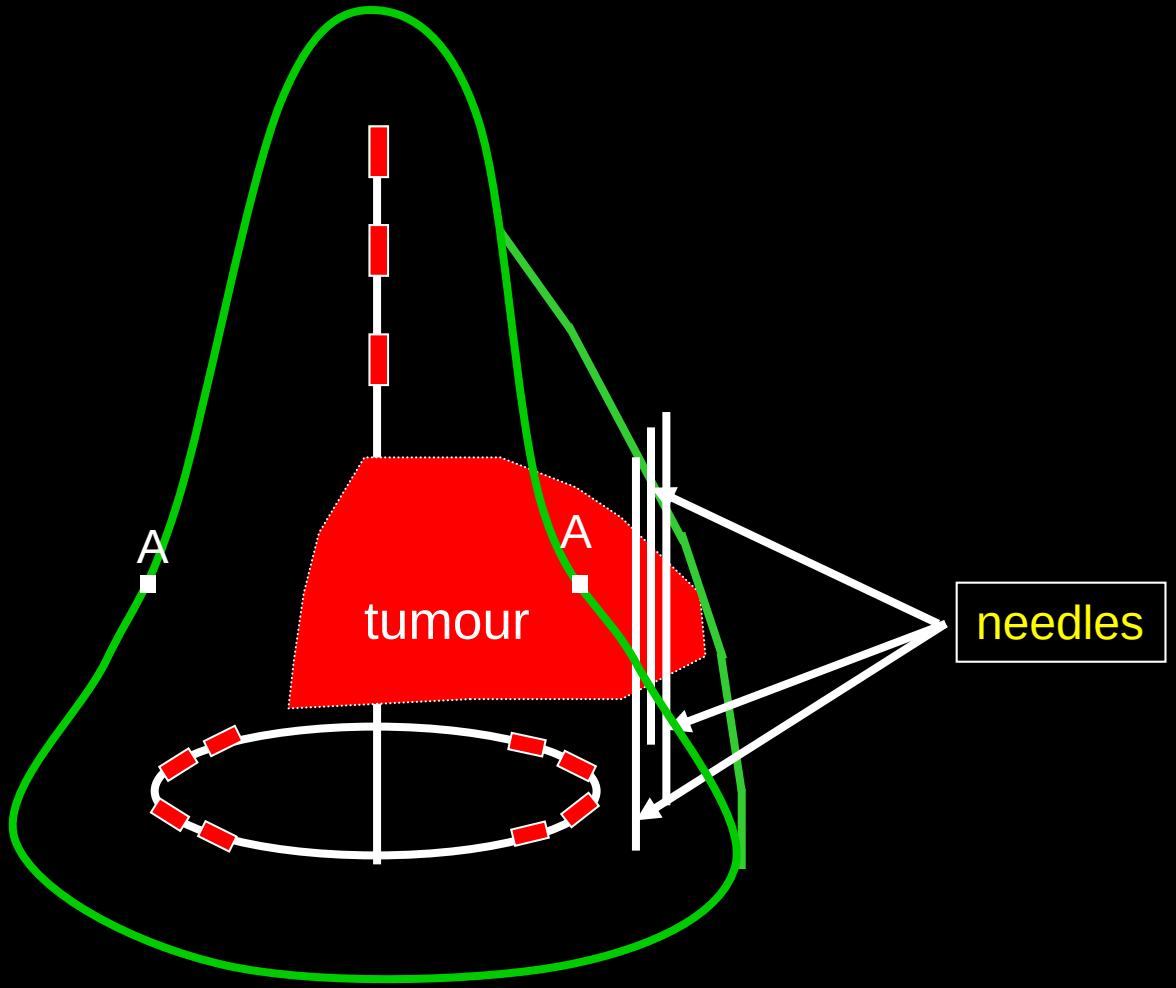
- Extensive Disease (IIB-IVA)
  (beyond cervix)



at diagnosis.

GYN GEC ESTRO Recommendations (I) Radioth.Oncol. 2005, 74:235-245

Coverage of asymmetrical tumour extension/ extensive disease at time of brachytherapy by additional use of needles



CONCLUSION

- Skilled use of intracavitary brachytherapy is the most crucial to a successful outcome

- Shift from point based dose prescription to image based target localization & treatment planning

TAKE HOME MESSAGE

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

Nag S 2005

Thank You