Brachytherapy of the Uterine Corpus: Some Physical Considerations

Bruce Thomadsen

University of Wisconsin -Madison

Conflicts of Interest

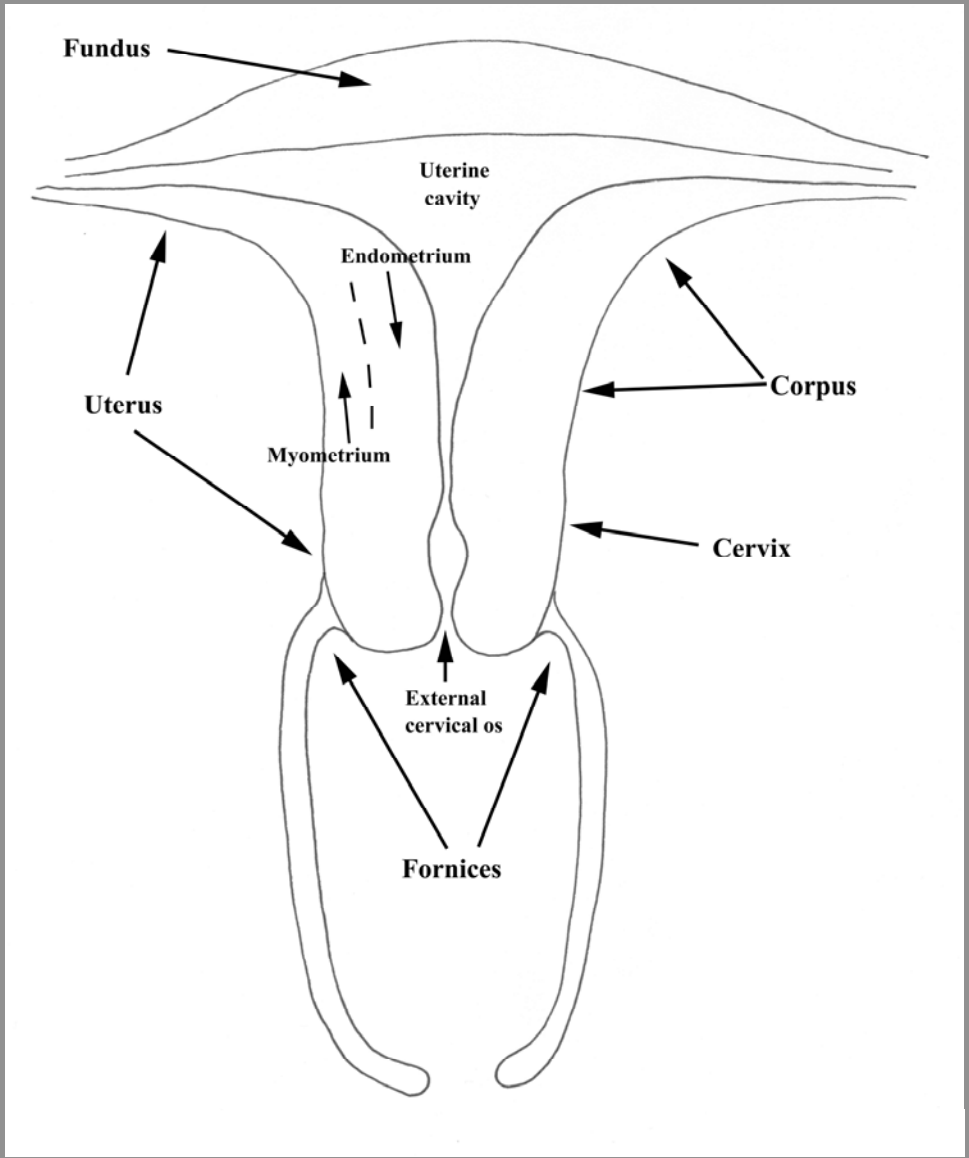
The author has no known conflicts involving this presentation

Learning Objectives

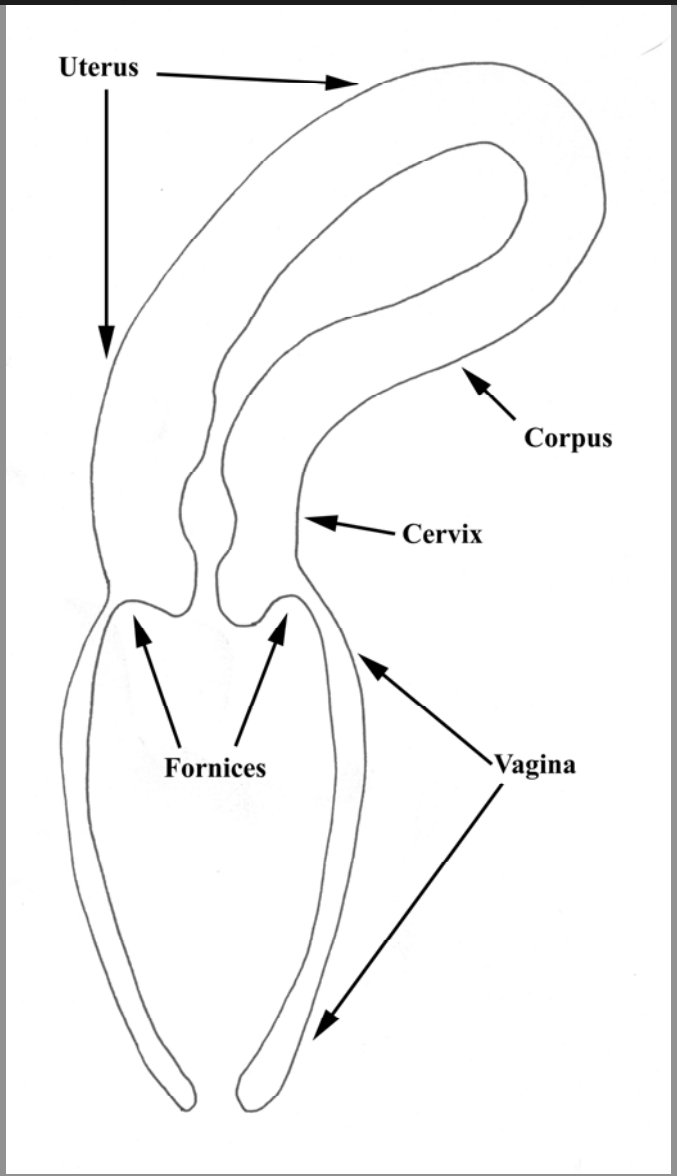
1. To learn the relationship between the pattern of disease and how they determine the treatment approaches for cancer of the endometrium.
2. To learn the treatment approaches for post-hysterectomy virginal-cuff irradiation.
3. To learn about treatment approaches and dosimetry for intact endometrial cancer brachytherapy.

Particular Challenges in Corpus Treatments

- Determining the target locations.
- Determining the doses to deliver to the targets.
- Achieving a distribution of radiation sources to fulfill the desired dose distribution.



Some Uterine Anatomy



Some Uterine Anatomy in a Sagittal Plane

Endometrial Cancer
Stage I- Inoperable

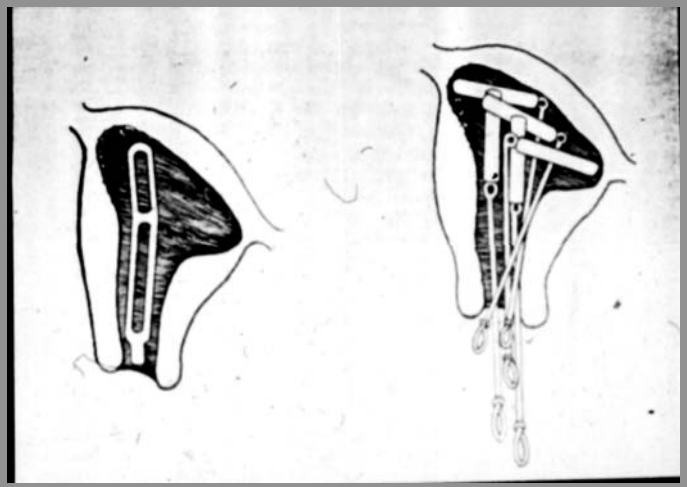
For "inoperable" patients, curative radiotherapy for this disease is not a benign procedure!

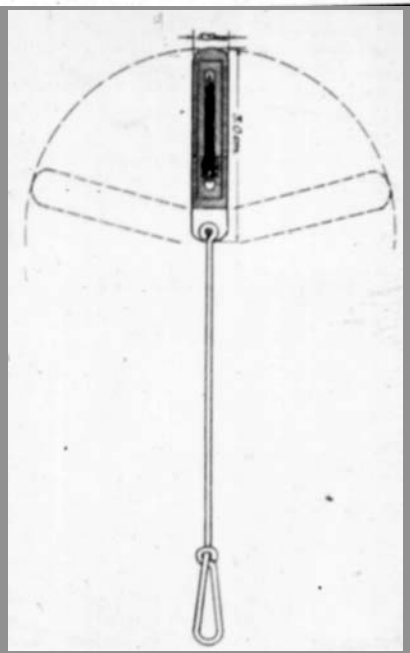
Endometrial Brachytherapy Problem

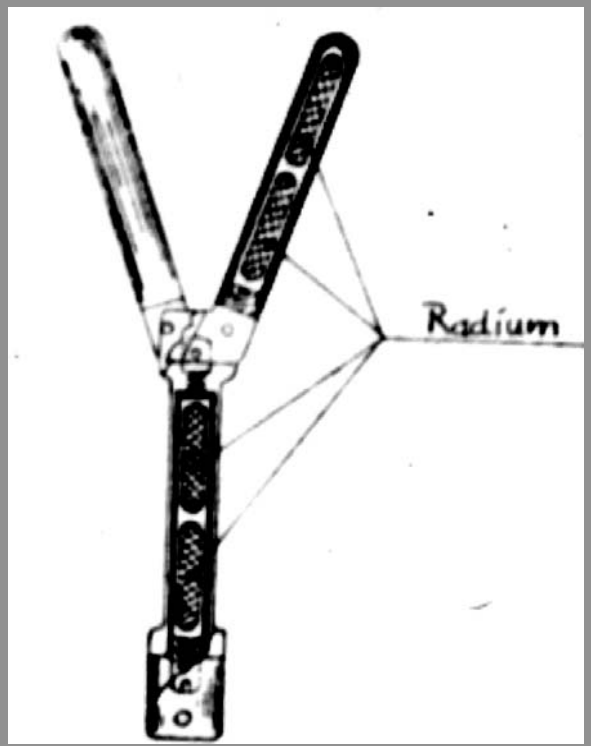
The difficulty with treating the corpus with intracavitary is getting enough radioactive material in the uterine cavity to deliver the dose at a reasonable rate.

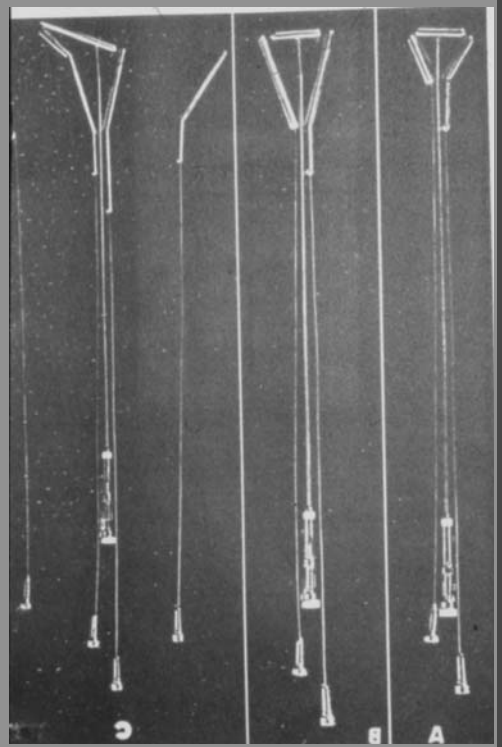
- Because the space is limited,
- With limited access,
- And the distances to the side wall are far at the top compared to small (relatively) on the bottom.

Martin- and Schmitz-Type Applicators

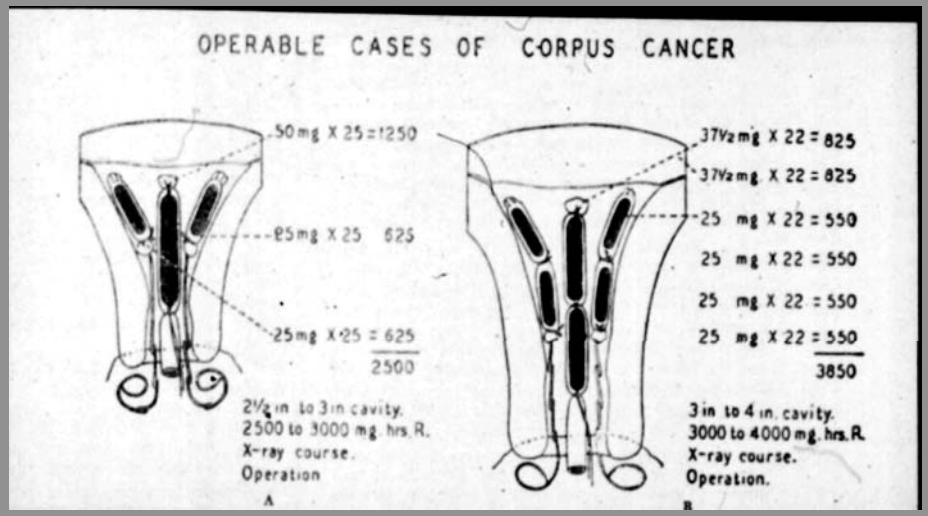


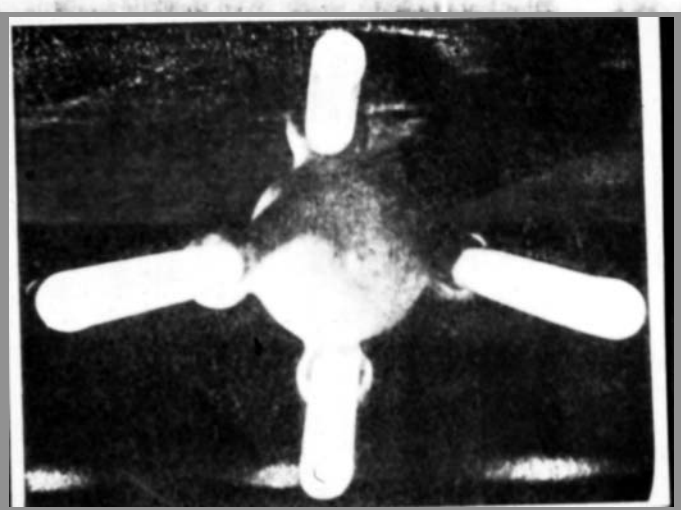


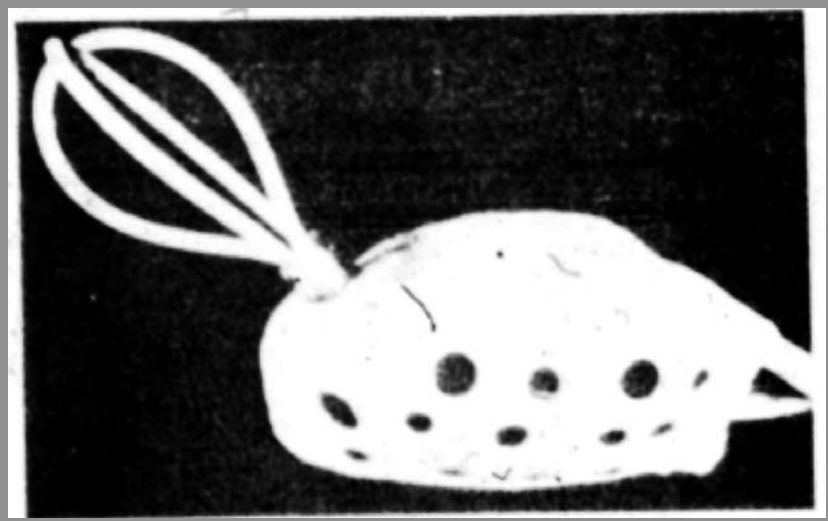




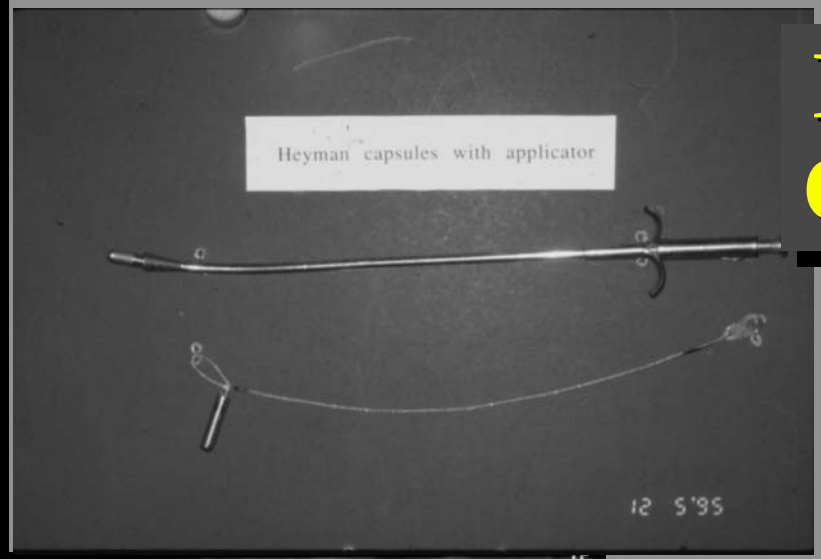
Some LDR Endometrial Applicators

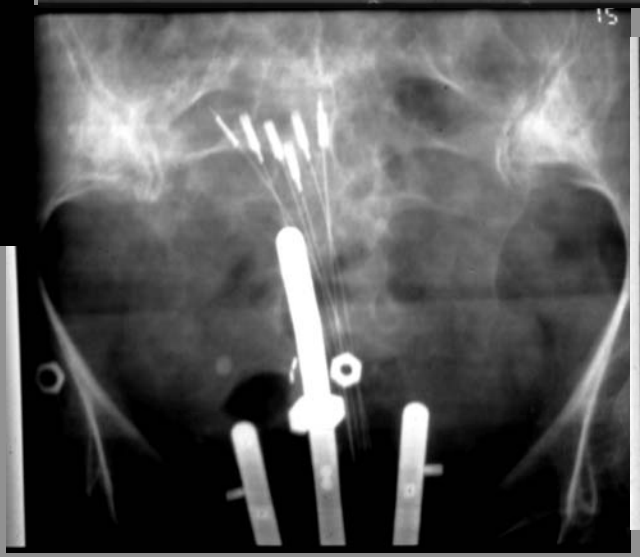


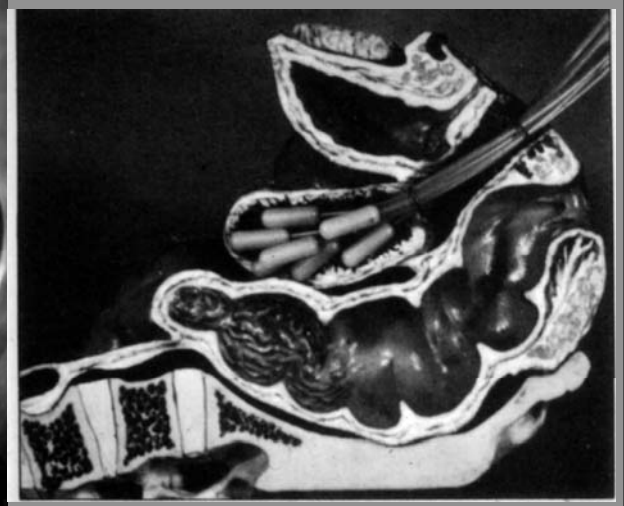




Heyman Capsules







Endometrial Cancer Stage I- Inoperable: Heyman Packing

Benner emphasized that the treatment duration could *not* be calculated by simply using a constant number of mg.hr.

Endometrial Cancer Stage I- Inoperable: Heyman Packing

Even so, one textbook said to use a constant 2500 mg.hr twice, separated by 3 weeks preoperatively, or 3000 mg.hr twice without a hysterectomy (or 2500 mg.hr three times two weeks apart for a large uterus)

(Fletcher 1966).

Endometrial Cancer Stage I- Inoperable: Heyman Packing

Nolan and Natoli measured that 6000-8000 mg hr gave about 67 Gy, and suggested that the maximum dose be kept below 144 Gy.

(1948)

Endometrial Cancer Stage I- Inoperable: Heyman Packing -Conversion to ^{137}Cs Afterloading

Differences compared with older radium applications:

- Capsule orientation (more axial) lowers dose to fundus.
- Fewer capsules increases time.
- Different "Γ" increases dose/mg hr.
- Different anisotropy.
- Less likely to tangle; harder to fit tandem.

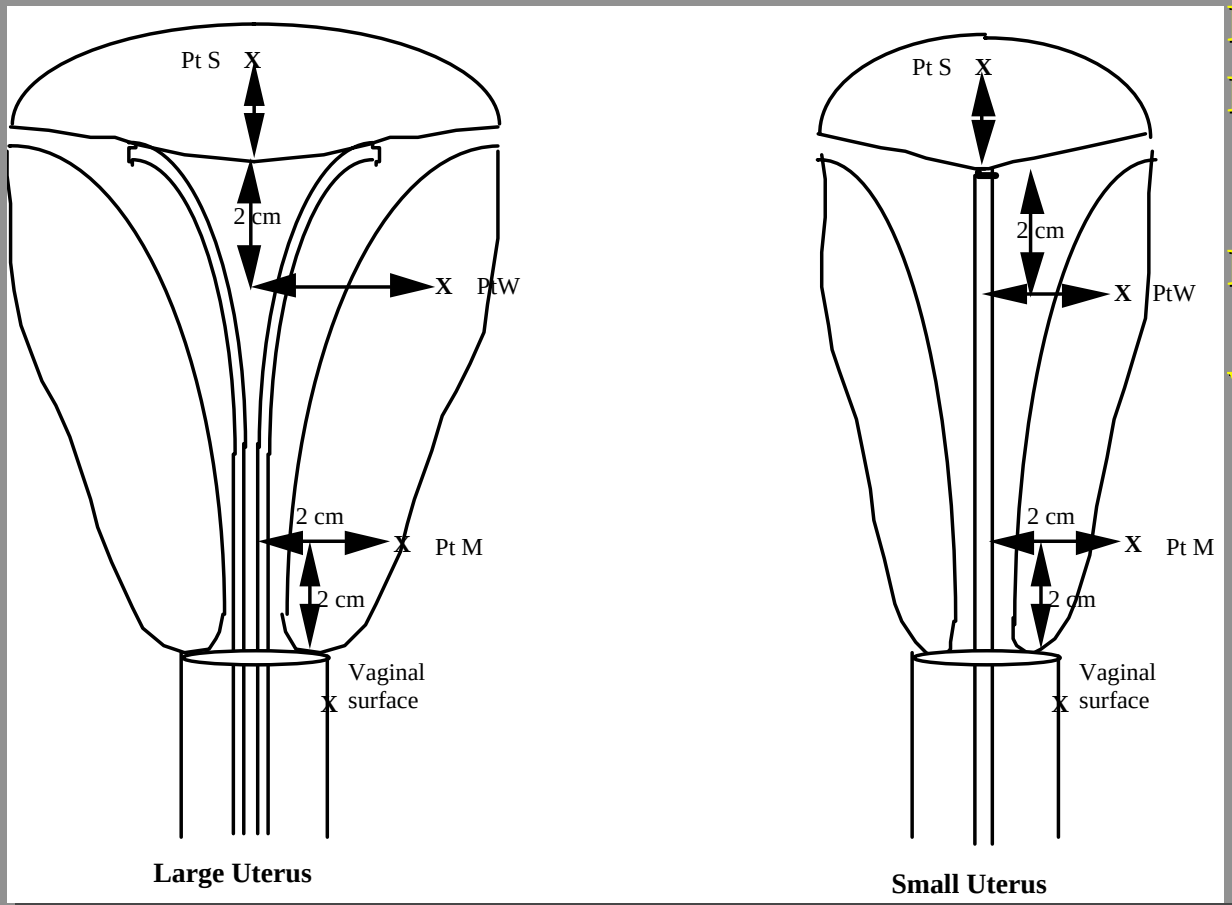
Endometrial Cancer
Stage I- Inoperable:
Conversion to HDR Remote Afterloading

- Need to determine important target sites.
- Need to determine desired doses.
- Need to determine appropriate applicator.

HDR Approach to Endometrial

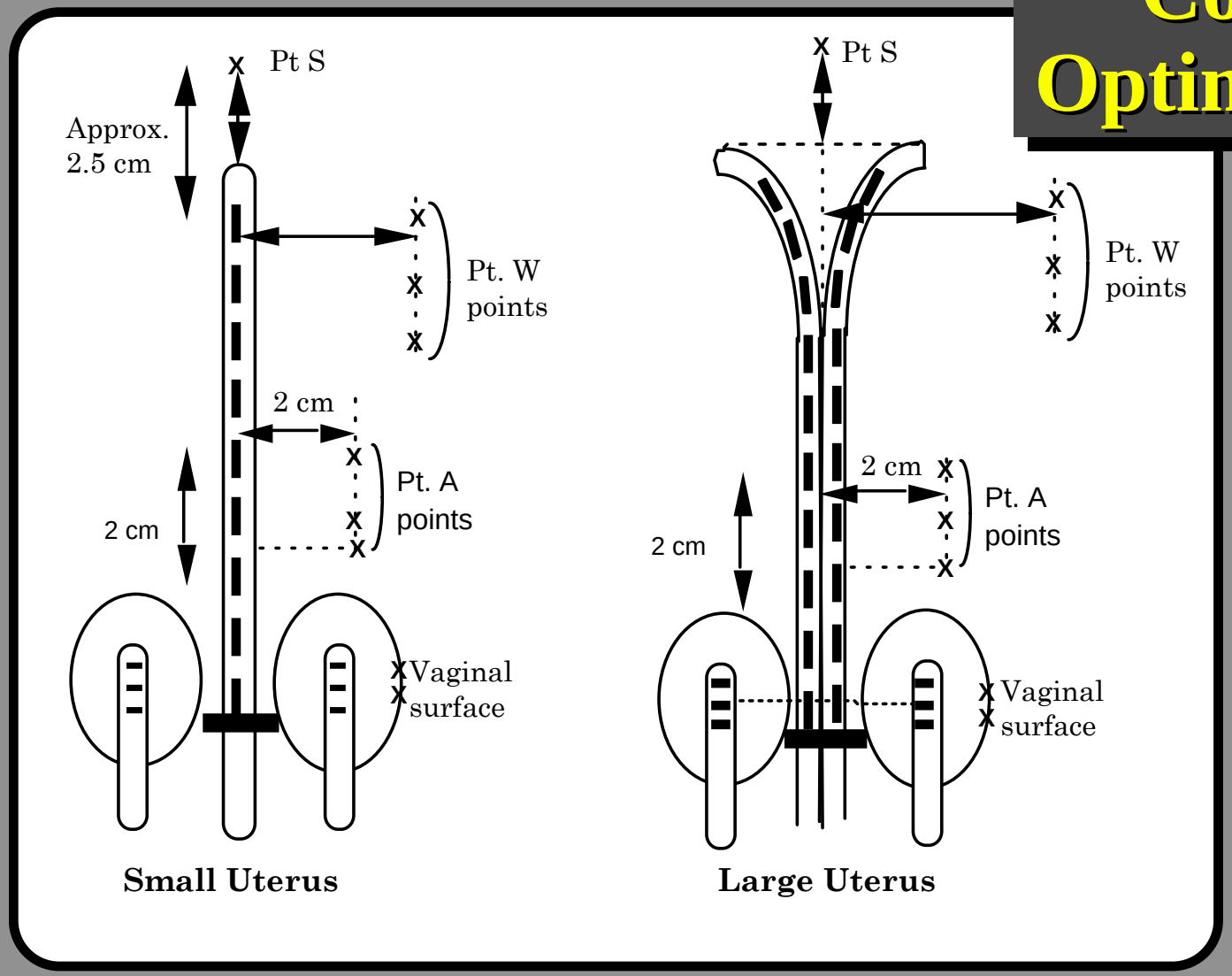
However, the problem of packing enough strength in the uterine cavity disappears.

Endometrial Cancer Stage I- Inoperable: Madison System Dose Points

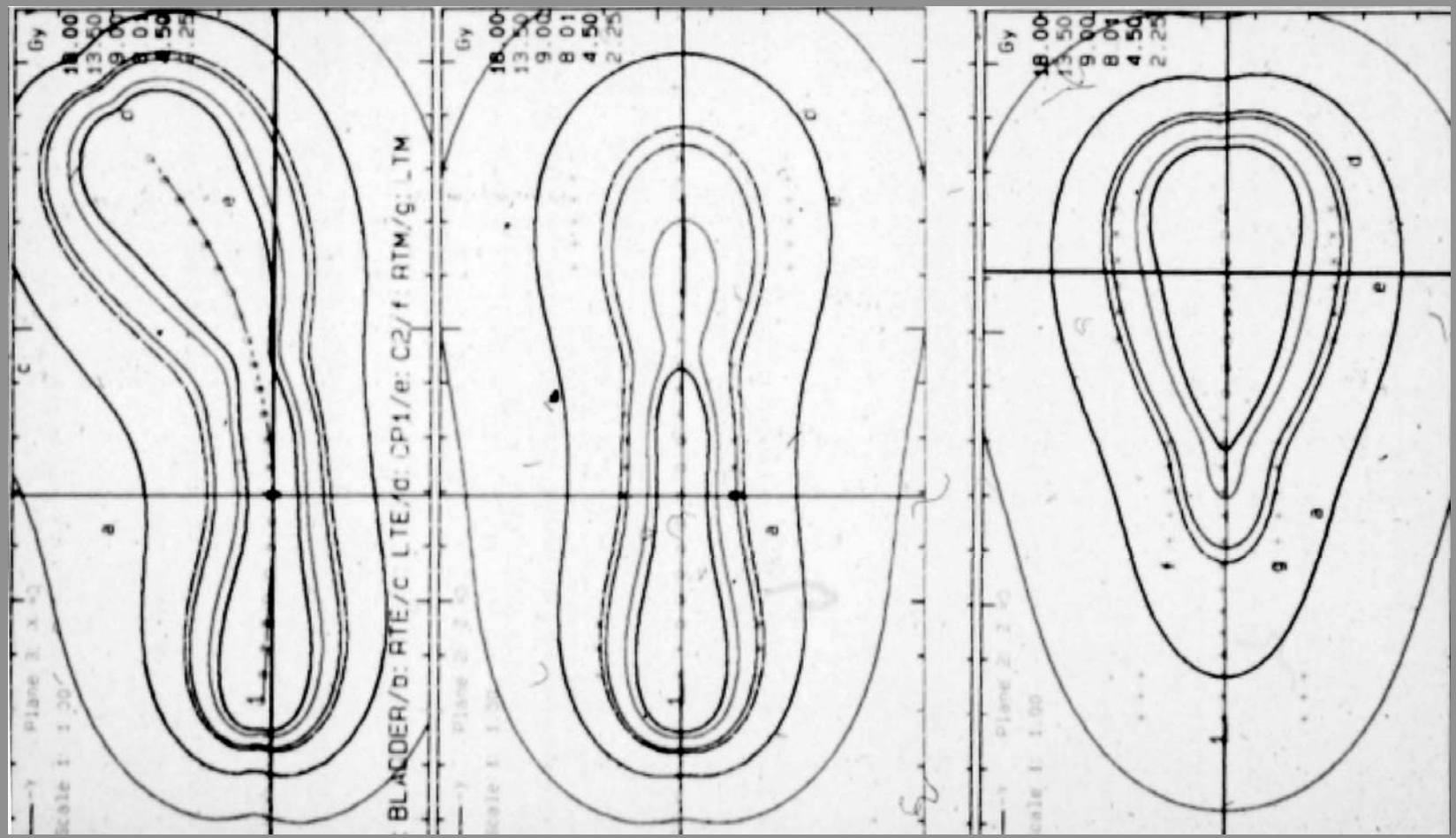


- **Point S - In the fundus**
- **Points W - In the superior myometrium**
- **Points M - At the paracervical triangle**
- **Vaginal surface - At the lateral aspect of the ovoids**

Corpus Optimization



HDR Isodose Curves



Operable Cases

Endometrial Cancer Stage I- Operable: General considerations

- Goal: Prophalaxys
- Target: Vaginal cuff
- Dose: 60 to 70 Gy LDR_{eq} to surface
- Constraints: Bladder and Rectum (of course)

Endometrial Cancer Stage I- Operable: Results

- Without radiation, 12% recurrence
- With radiation, 0% recurrence

Graham, 1971

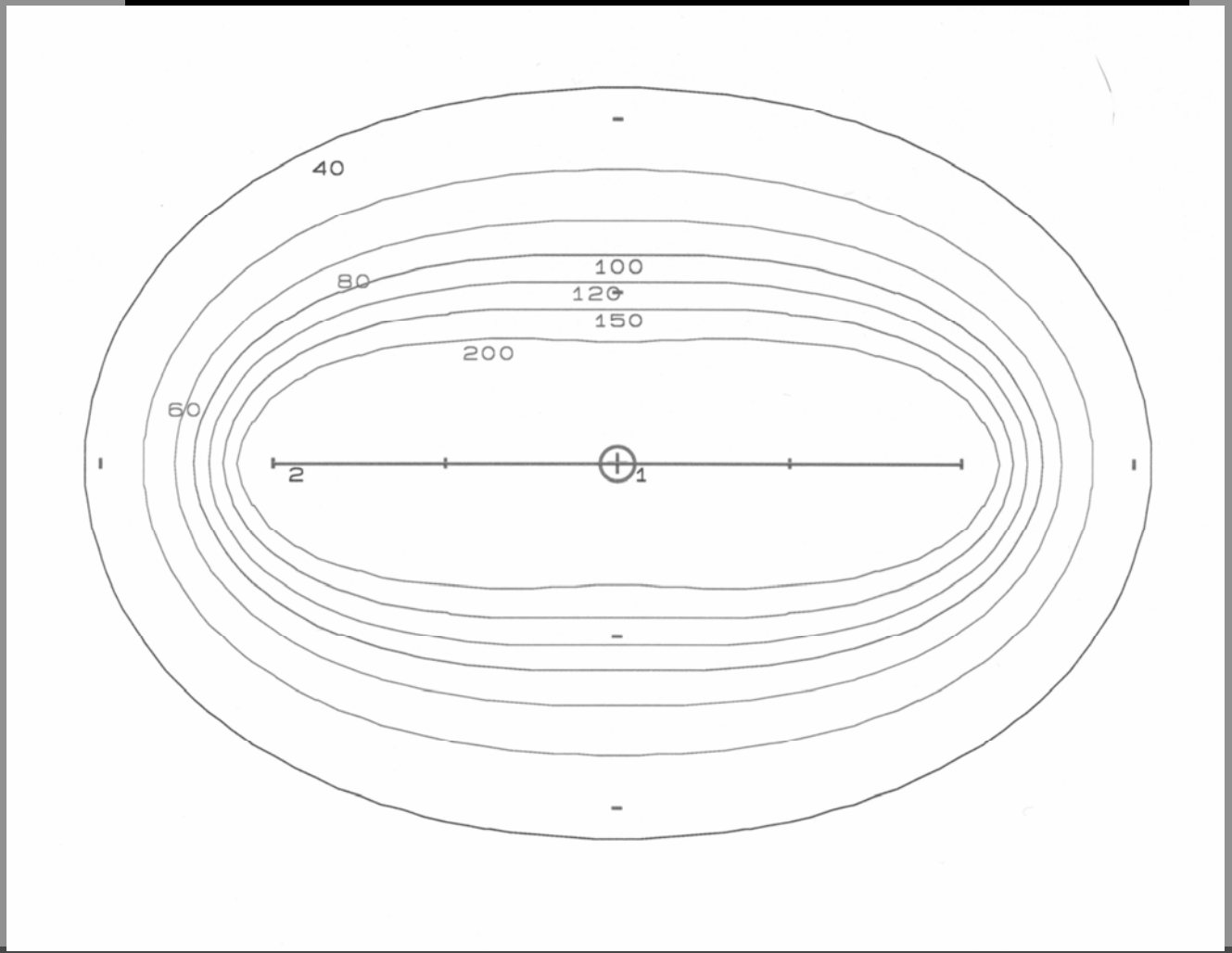
Vaginal Cylinders

Vaginal Ovoids

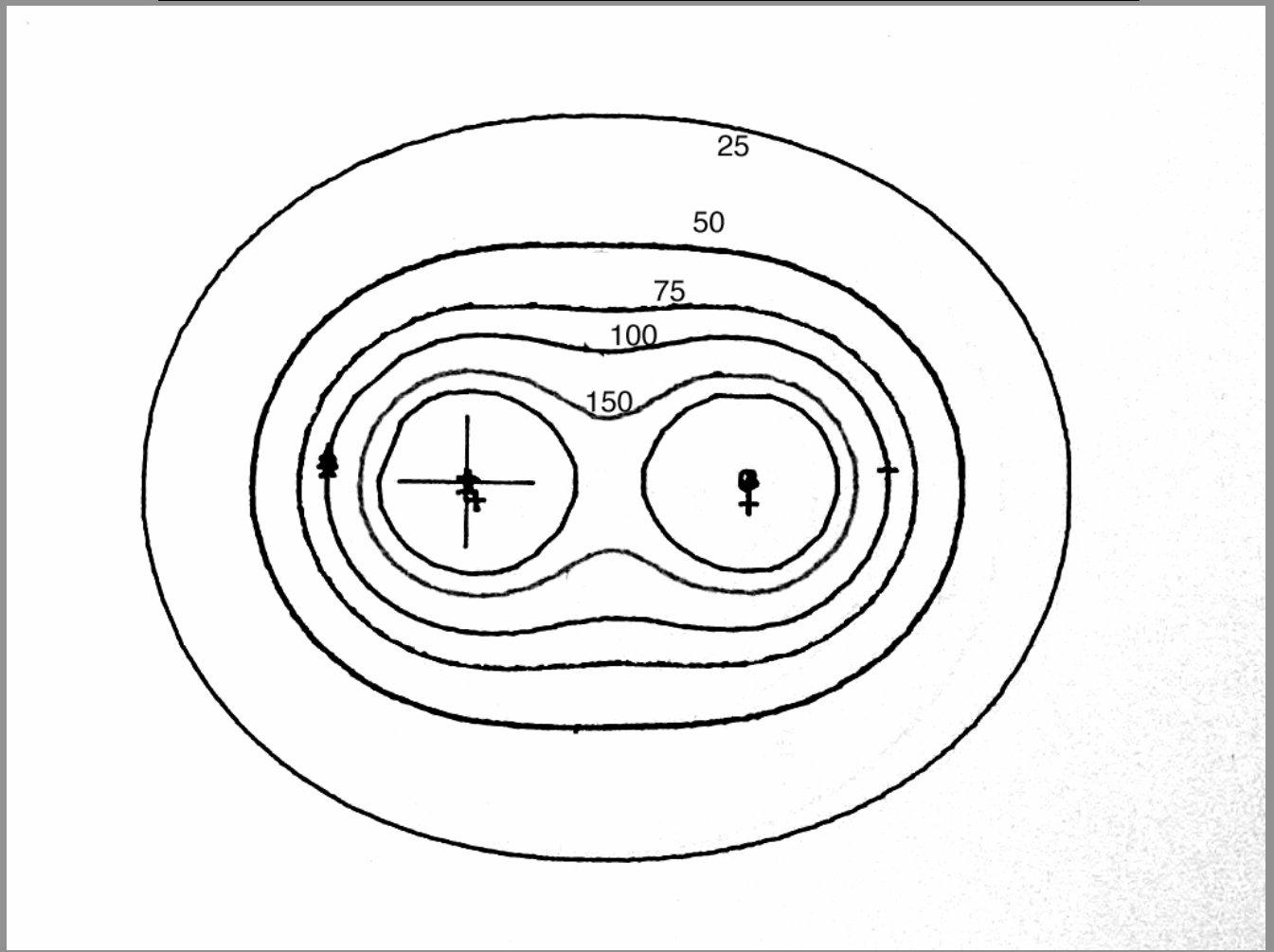
Endometrial Cancer
Stage I- Operable: Appliance

- **Tandem and Ovoids**
  - Limits dose to vaginal cuff
  - With LDR, can shield bladder and rectum (partially)
  - With HDR can displace bladder and rectum (partially)
  - Source anisotropy lowers doses to the bladder and rectum
- **Cylinder**
  - Usually covers more of the vagina
  - Alignment make it difficult to shield the bladder or rectum with LDR
  - Space makes it difficult to displace the bladder or rectum with HDR
  - Source anisotropy increases the dose to the bladder and rectum

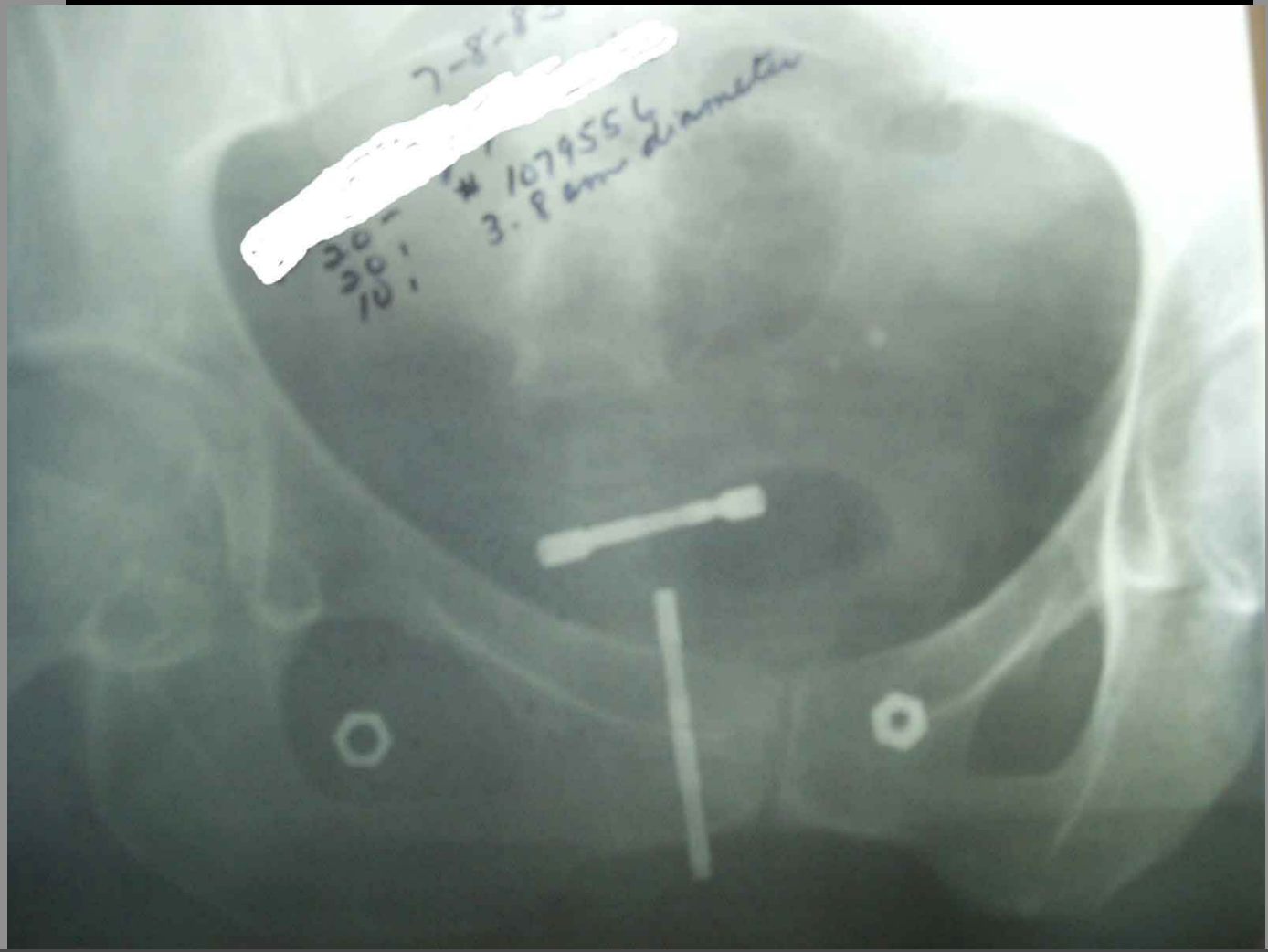
Cylinder Dose Distribution



Ovoid Dose Distribution

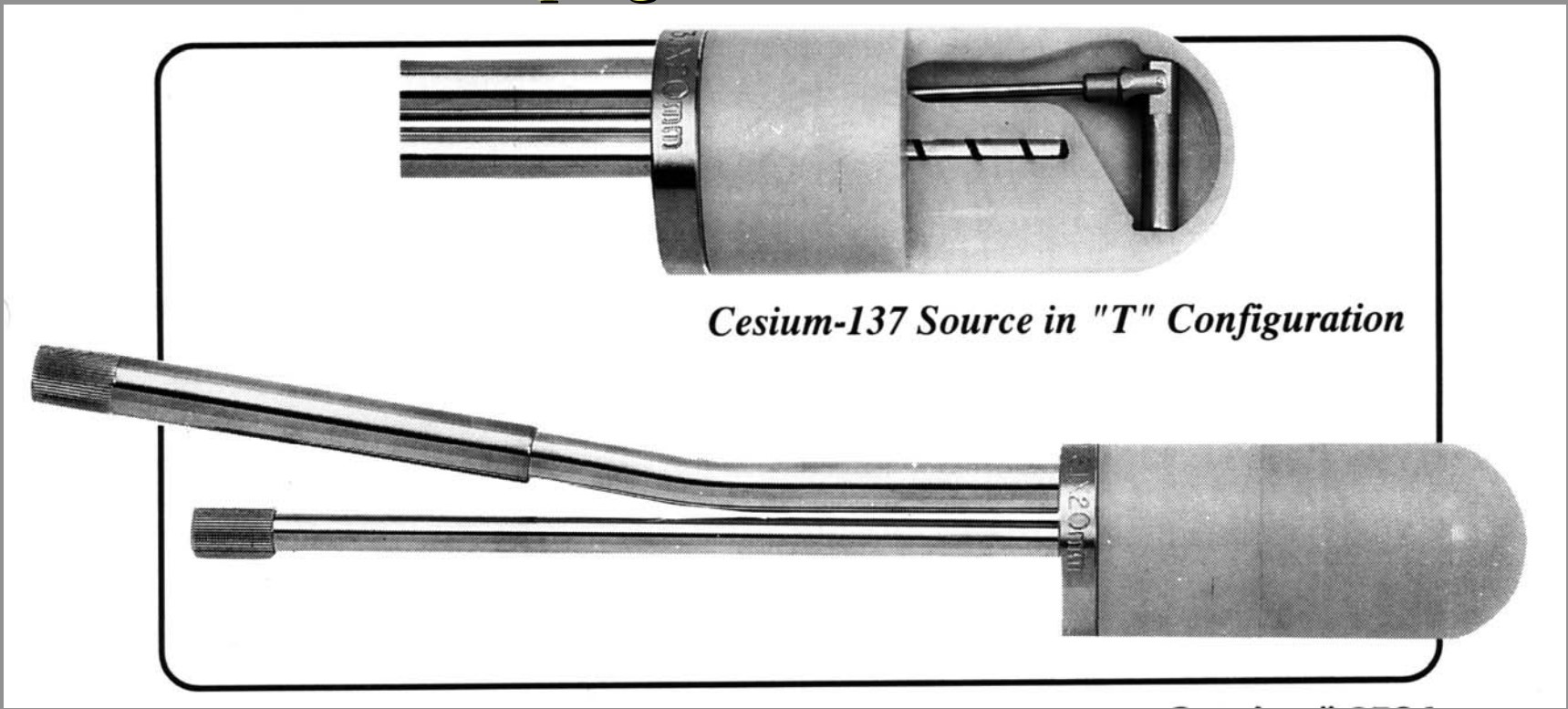


Cylinder with Crossing Source



Endometrial Cancer
Stage I- Operable: Appliance

Wang designed an afterloading cylinder with the lead source that sits upright.



Endometrial Cancer
Stage I- Operable: Appliance

Ovoid type	Ovoid radius [cm]	Dose at 0.5 cm relative to surface
Mini	1.00	0.53
Small	1.00	0.52
Medium	1.25	0.56
Large	1.50	0.62

Endometrial Cancer Stage II- Operable: Postop

Treated as a Stage I Operable except with the addition of external beam.

Endometrial Cancer Stage II- Operable: Preop

Treated as a cervix cancer, specifying the dose to Points A, where the surgeon will cut, without regard to the dose to Points S or W.

Endometrial Cancer Stage II- Inoperable:

Treated as a Stage I Inoperable, except with the addition of external beam.

Endometrial Cancer Stage III

- Operable (preop): Intent is to shrink the tumor for surgery and sterilize the vaginal cuff, mostly through external beam, with the brachytherapy as a boost. Treatment is similar to Stage II operable.
- Inoperable: Treatment concentrates on external beam, with the brachytherapy boost customized to the disease.

Endometrial Cancer Stage IV

The goal is to alleviate symptoms , so each application depends on the disease and patient.

Dose Specification (1)

- **Emitted dose systems**
  - i.e., mg·hr based systems
  - Actually gives something related to integral dose
  - Doses to anatomical locations vary widely between patients
  - Does not account for variations in applications
  - Sometimes use doses to nontarget, critical organs as a limiting factor

Dose Specification (2)

- **Defined-point Dose System**
  - e.g., Manchester System with Point A
  - Assumes that the definition correctly and accurately locates the point of interest.
  - Assumes that the point on interest determines important aspects of the treatment
  - Assumes that the definition applies practically and unambiguously to all patients
  - Assumes that specifying the dose to the point sufficiently specifies the dose to the application, possible through additional rules

Achieving the Desired Dose Distribution (1)

- Remote Afterloaders allow better flexibility to obtain the desired distribution.
- Inverse linear/square limits ability to deliver doses at distance without overdosing near tissue.
  - Can always push the dose to a given location.
  - single line (tandem and cylinders) may not be appropriate for bulky disease.
- Interstitial implants can help reach out towards the pelvic sidewalls.

Achieving the Desired Dose Distribution (2)

- In general, the largest diameter ovoids that fit should be used and spreading avoided.

Achieving the Desired Dose Distribution (3)

- Shielding in the ovoids
  - May not be necessary for post-op.
  - May only reduce dose to the Foley bulb, but not the bladder most at risk.
- HDR and PDR probably not as important for post-op due to limited complications.