

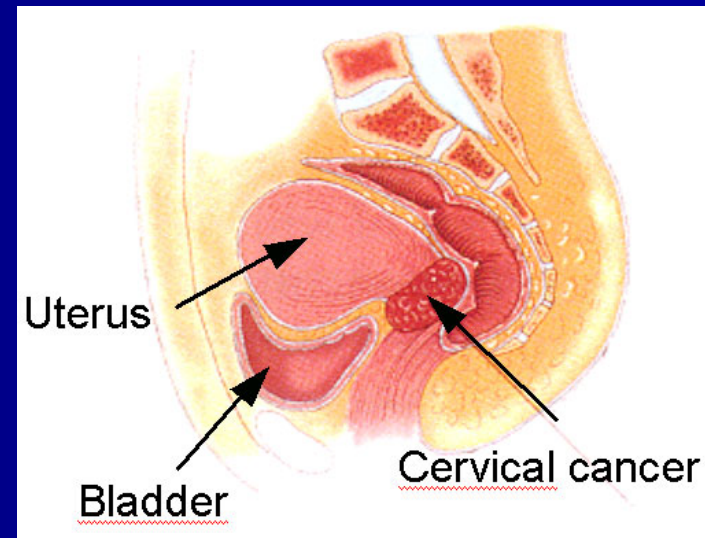
MANCHESTER SYSTEM FOR GYNECOLOGICAL APPLICATIONS

Anil Sharma, PhD

'Radium treatment' of uterine cervix

The use of Radium sources for treatment of uterine cervix started in 1903. The dose prescription was entirely empirical due the lack of:

- knowledge about the biological effects of radiation on the normal tissues and the tumor
- understanding about the dose, dose distribution and the duration of treatment



Dosimetric Systems

- Dosimetric systems are set of rules, specific to a radioisotope and its spatial distribution in the applicator to deliver a defined dose to a designated region
- Within any system, specification of treatment in terms of dose, timing, and administration is necessary so as to implement prescription in a reproducible manner.

Dosimetric Systems

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graph TD; A[Dosimetric Systems] --> B[Stockholm system]; A --> C[Paris System]
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Stockholm system

Paris System

Stockholm system

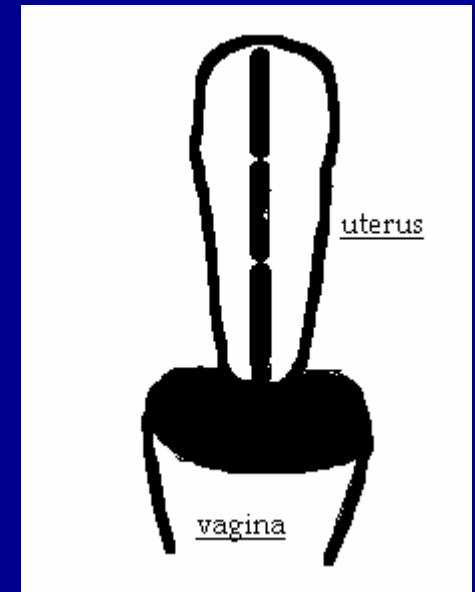
- Fractionated (2-3 applications) delivered within about a month
- Each application 20-30 hours
- The amount of Radium was unequal in uterus (30-90 mg, in linear tube) and in vagina (60-80 mg, in shielded silver or lead boxes)
- Vaginal and uterine applicators were not fixed together
- Total mg-hrs were usually 6500 to 7100 out of which 4500 mg-hrs were in vagina.

Paris System

- Single application
- 5 days to deliver 7200-8000 mg-hrs.
- Almost equal amounts of Radium were used in uterus and vagina
- The intrauterine tube contained three sources in the ratio of 1:1:0.5
- Two cork intravaginal cylinders (colpostats) had one source each of almost the same strength as the top intrauterine source.

Stockholm and Paris Systems

- Uterine sources in both systems were arranged in a line extending from the external os to nearly the top of the uterine cavity
- Both systems preferred the longest possible intrauterine tube to increase the dose to paracervical region and pelvic lymph nodes
- There was a limited use of external beam therapy in Stockholm system, whereas Paris system used external beam therapy before the implant



Dose specification problems

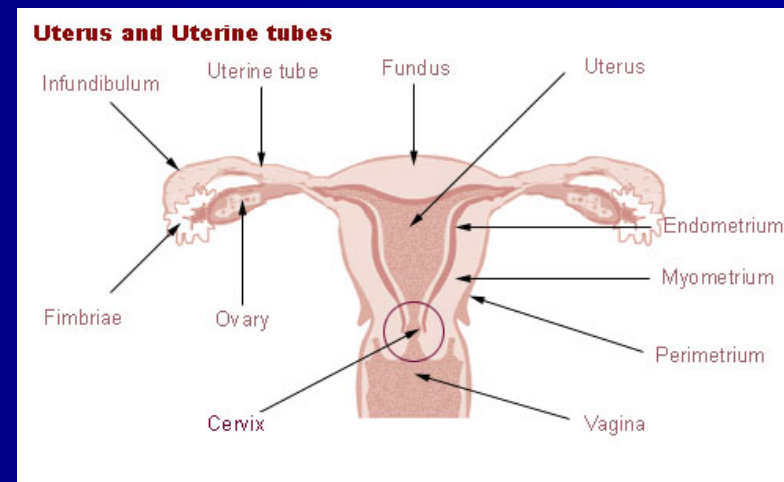
1. When intracavitary therapy, *specified in mg-hrs*, is used in conjunction with external beam therapy, *specified in terms of absorbed dose*, overall radiation treatment cannot be adequately defined
2. Dose prescription in terms of mg-hrs ignored anatomical targets and tolerance organs.

Manchester Approach – *first step*

- Define treatment in terms of dose to a point *representative of the target, i.e., uterus*, more or less reproducible from patient to patient.

Search for a dose specification or limitation point

To define the actual dose delivered in “fixed mg-hr systems” in a more meaningful way, Tod and Meredith began to calculate the dose (in roentgens) to various sites in the pelvis by defining a series of points anatomically comparable from patient to patient.

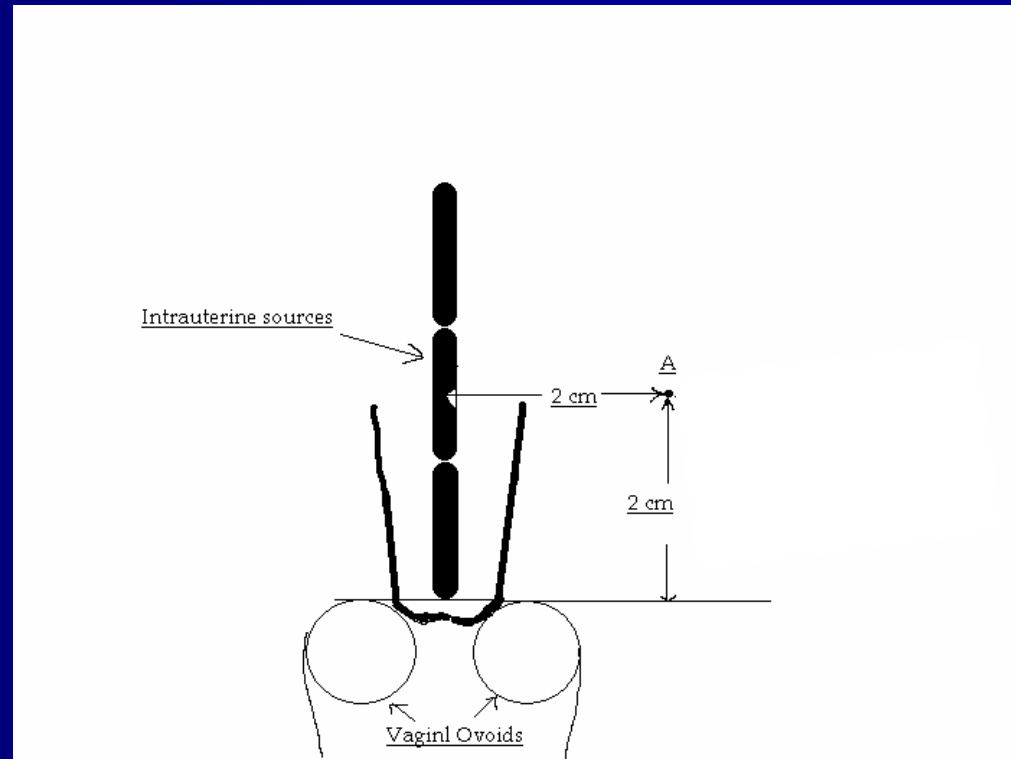


Tod and Meredith's findings

- Obvious sites for dose prescription, such as cervix itself, were not suitable due to the high dose gradient inherently present in that region
- Limiting radiation dose was not the dose to the critical structures, such as the rectum or bladder, but *to the area in the medial edge of the broad ligament where uterine vessels cross the ureter*
- To this pyramid shaped area, the base of which rests on the lateral vaginal fornices and apex curves around the anteverted uterus, the name "Paracervical Triangle" was given.
- It was considered that the tolerance of this paracervical triangle, is the main limiting factor in the irradiation of uterine cervix.

Original Point 'A' definition

2 cm lateral to the uterine canal and 2 cm from the mucous membrane of the lateral superior fornix of the vagina in the plane of the uterus.

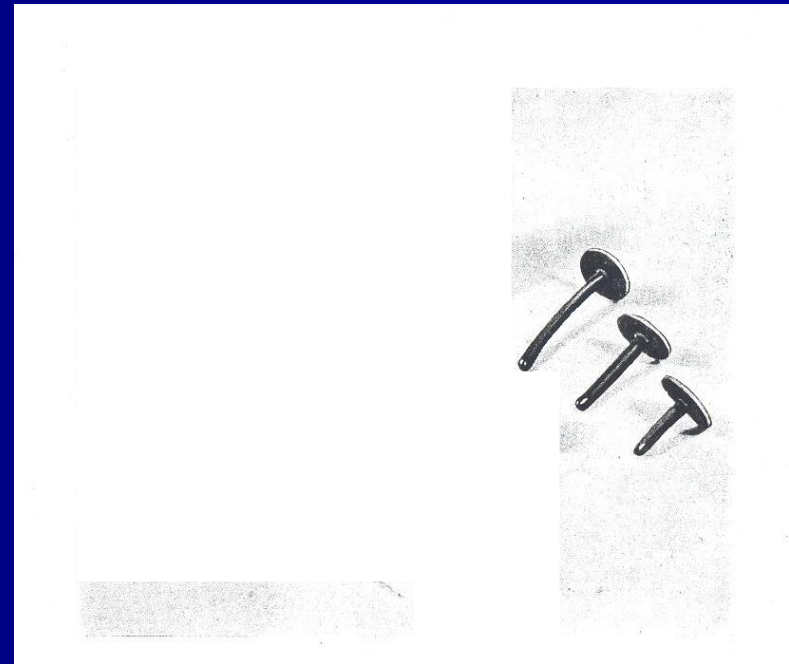


Manchester Approach – *second step*

- Design **applicators** and their loading to enable the same dose-rate to this point 'A' regardless of which combination of applicators is used.

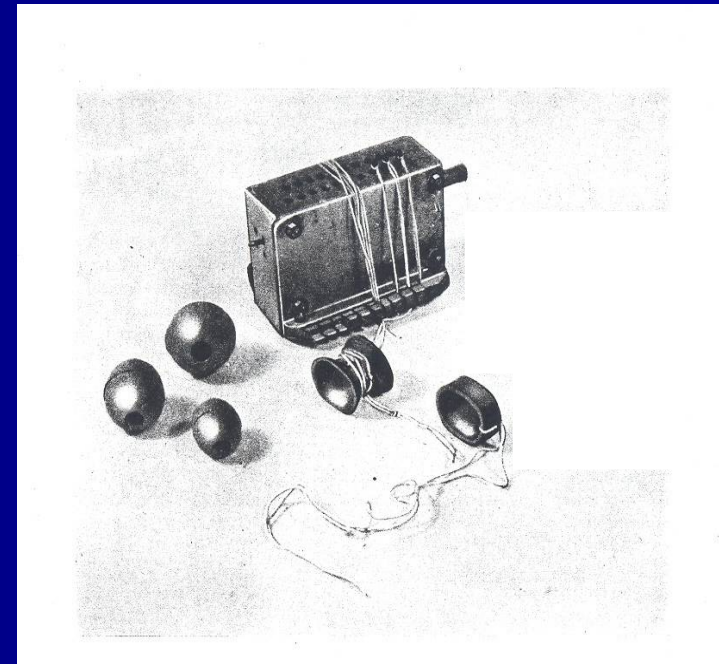
Applicators - *Intrauterine Tubes and Ovoids*

- The intrauterine tubes of thin molded rubber or plastic with one end closed and supporting a flange at the other end for aiding fixation.
- Available in three lengths, meant for one, two or three radium tubes.



Vaginal Ovoids

- The vaginal applicators (ovoids) were made of hard rubber or plastic with diameters of 20, 25 or 30 mm, mimicking the shape of isodose surface around a radium tube of 15 mm length
- The ovoids were used in pairs, one ovoid in each lateral vaginal fornix at the level of cervix
- The ovoids were designed not only to be adaptable to the different sizes of the vagina, but also to take advantage of vaginal capacity to carry the radium laterally



Manchester Approach – *third step*

- Define *a set of rules* dictating the relationship, position, and activity of radium sources in the uterine and vaginal applicators to achieve the consistent dose rates

Radium Sources and Their Loading

- A 'unit' of radium containing 2.5 mg of 1mm Pt filtered radium was defined and all loadings in the intrauterine tube and vaginal ovoids were made integral multiples of this unit.
- Long intrauterine tube with 3 sources contained 4, 4, 6 units, medium intrauterine tube with 4, 6 and short with 8 units. Large, medium and small ovoids were assigned 9, 8, and 7 units in each ovoid.

Dose Specification

- Optimal total dose to point 'A': 8000 R
- Number of sessions: 2
- Duration of each session: 72 hours
- Interval in between sessions: 4-7 days
- This implied a *dose rate of 55 R per hour* which was achieved by the strict loading rules
- Not more than about one-third of the total dose at point 'A' was delivered from radium in the vaginal ovoids.

Manchester System

Modification of Paris and Stockholm systems

- source loading technique of Paris system
- fractionated delivery of dose from the Stockholm system.

Manchester System

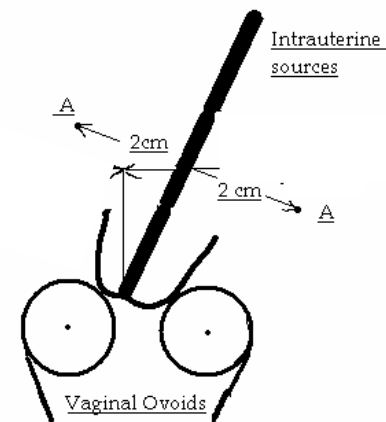
This concept of the statement of dosage to a single point, made this system as the most acceptable brachytherapy technique for the treatment of cervical cancer.

The source loading rules were defined in a way that point 'A' received same dose rate no matter which ovoid and intrauterine combination is used.

Modified Point 'A'

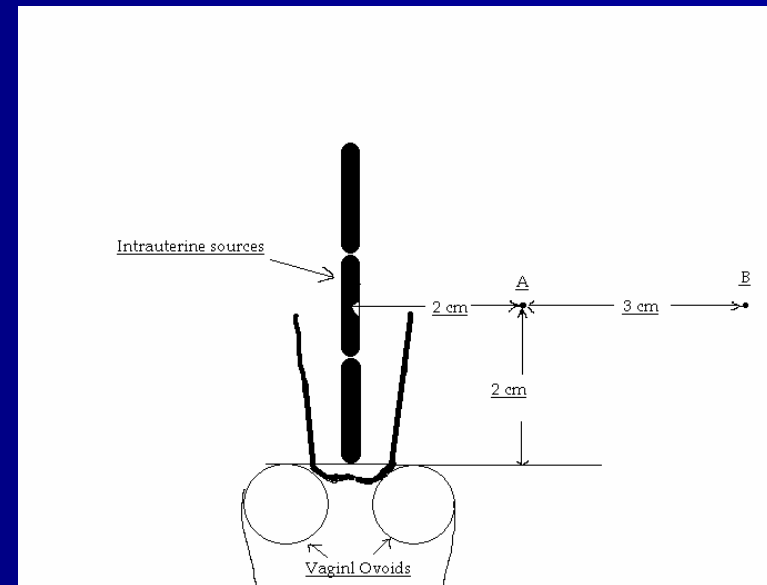
Although point 'A' was defined in relation to important anatomical structures, these cannot be revealed on a radiograph.

So point 'A' definition was modified in 1953 and is sometimes denoted as Ao (o stands for external os).



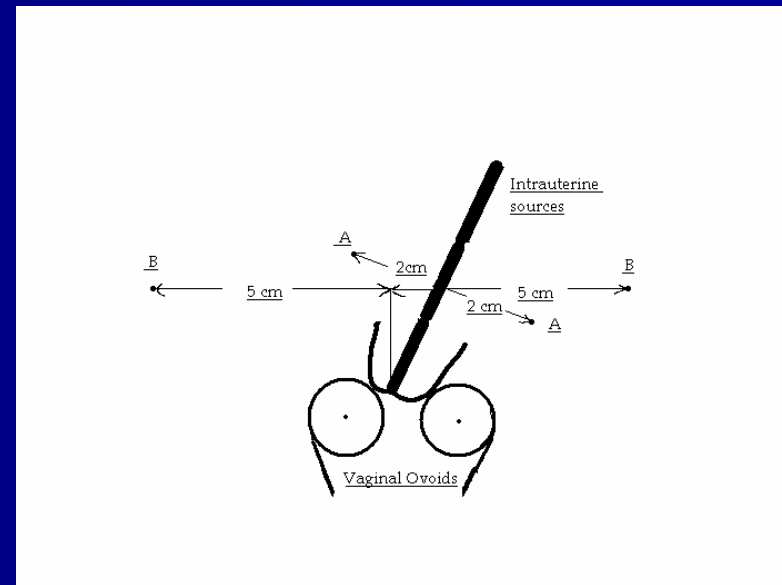
Point 'B'

- While the dose to point 'A' was considered to be the most useful index of limiting dosage which can be given, the lateral fall off of the dose was also considered important. For this reason a further reference point B, was also defined to be 5 cm from the mid-line and 2 cm up from the mucus membrane of the lateral fornix.
- This point was chosen since it gives not only the dose in the vicinity of the pelvic wall near the obturator nodes, but also a good measure of the lateral spread of the effective dose.
- The dose at point B depends very little on the actual geometrical distribution of radium, such as the size of the ovoids and intrauterine tubes, but almost entirely on the total amount of the radium used.



Point 'B'

- In those cases where the uterus does not lie in the mid-line of the body, the tissues in which point 'A' lies is considered to be carried with the uterus, but point B, which does not directly depend on the uterus, remains as a fixed point, 5 cm laterally from a point 2 cm up the midline from the end of the radium tube.
- In the loading rules of the Manchester system, it was recommended that, if possible, largest ovoids be used to carry the radium close to point 'B' and increase the depth dose. It was advised to place the ovoids as far laterally as possible in the fornices for the same reason.



Other Dose Limiting Structures

- Vaginal Mucosa
- Rectovaginal Septum

Vaginal Mucosa

“The tolerance of vaginal mucosa is such that not more than about 40% of the total dose to point 'A' can safely be delivered through the vaginal ovoids and this should be taken into account in planning the differential loadings”

Paterson

Rectovaginal Septum

- Dose to the recto-vaginal septum for any technique should be less than that at point 'A'.
- Dose to this area can be reduced to less than 80% of the dose to point 'A' by carefully packing gauze to a thickness of at least 1.5 cm to pack ovoids away from the rectum.

Radium substitutes and mgRaeq concept

- Radioisotopes like ^{137}Cs and ^{192}Ir , require simplified protection both in terms of thickness of barrier required to provide adequate protection and as well as the absence of gaseous radioactive daughter product.
- Dose distributions in tissue from these isotopes are not much different from those produced by radium because they too have energy higher than 300 keV and their dose distribution is not greatly affected by their energy, essentially following the inverse square law.
- These sources, called radium substitutes, can be calibrated in terms of a quantity that allows the use of radium tables without modification.

Radium substitutes and mgRaeq concept

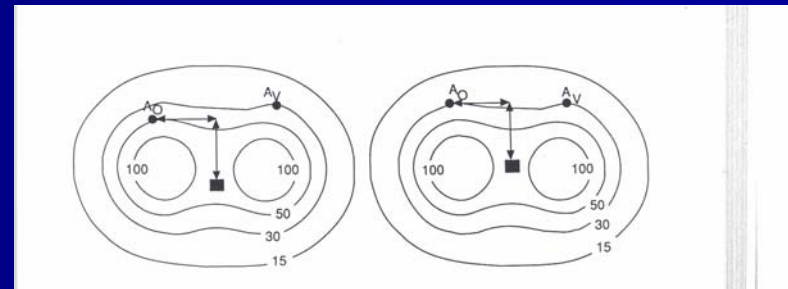
- The source strength is specified in terms of the mass of radium that would produce an equivalent exposure rate at a distance 1 m on the transverse axis of the source. One effective equivalent mass of radium, mgRaeq, of a radium substitute yields an exposure rate, at one meter, of 0.825 mR/h.
- So, although this unit appears to be a unit of mass, it actually is a specification of the exposure rate at a distance. However, the mgRaeq of a source is not necessarily the ratio of the exposure rate constant of the radium substitute to radium. Source geometry and filtration should also be accounted for the equivalency.

Relevance of the Manchester system today

- Manchester system was meant for radium as the radioisotope and applicators specially designed to accommodate those sources following a set of rules to deliver almost a constant dose rate to its dose specification point 'A'. Any variations in the selection of source, applicator or the set of rules will result in dose delivery which most likely be different from that dictated by the Manchester system.
- With radium being all but replaced by ^{137}Cs (LDR and MDR) and ^{192}Ir (HDR) and to a lesser extent by ^{60}Co (LDR and HDR), it is imperative to look into the relevance of Manchester system in modern times.

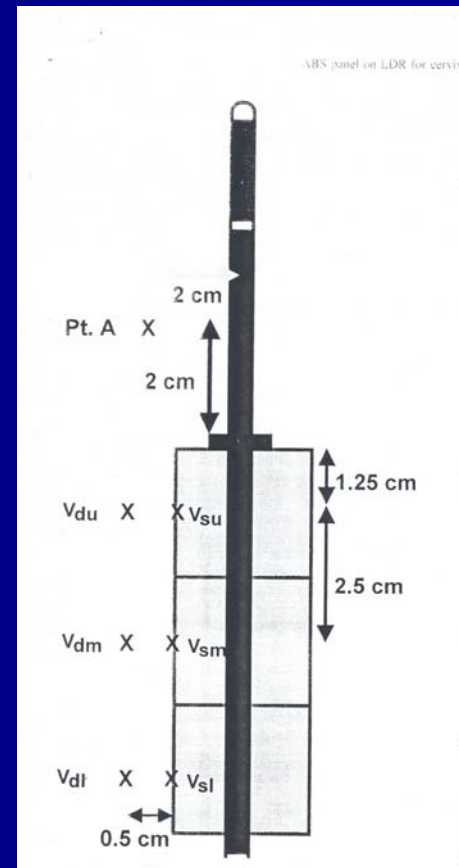
Other Dose Specification Points as Variation of Point 'A'

- Over the years, point A has been defined in many ways. Point Av (v stands for vagina) was proposed as 2 cm lateral to the mid point of the cervical collar and 2 cm above the top of the colpostats (Potish, 1987), measured at their intersection with the tandem mid point on the lateral radiograph.



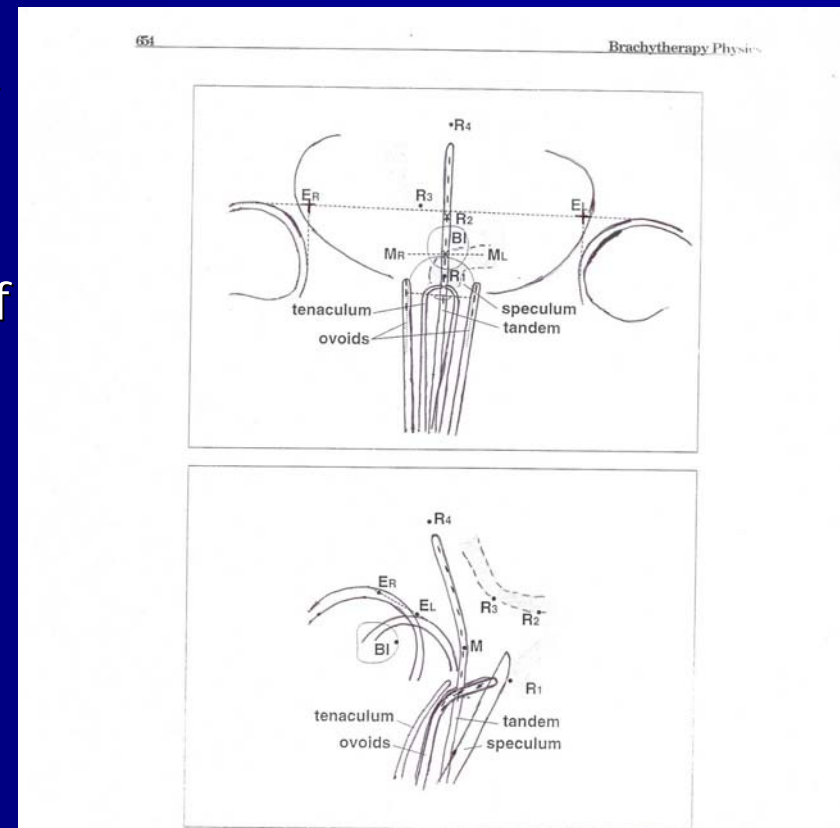
ABS Recommendations

For tandem and vaginal cylinder, the localization of point A can be carried out as follows: from the flange of the tandem, move 2 cm superiorly along the tandem and then laterally 2 cm perpendicular to the tandem on both sides of the AP radiograph



Point 'M'

- In 1993, for a specially designed system (Madison system for HDR brachytherapy of uterine cervix), point M was defined. It lies 2 cm cephalad along the tandem from a line connecting the center points of the vaginal ovoids and 2 cm perpendicular to the tandem, when using 1 cm radius ovoid caps. In this system, the uterus is held lower in the pelvis (using tenaculum) to lower the small bowel dose superior to the uterus. In this situation, this point M approximately coincides with original point A of the Manchester system.



Fletcher System

- Fletcher system, defined several other points to account for the dose to regional lymph nodes and pelvic points.

Afterloading Technique

- In the beginning, manual afterloading was the direct extension of the conventional preloaded applicator system using radium sources.
- Today, manual afterloading applicators are modified to accommodate ^{137}Cs sources, but still follow the dosimetry associated with their original pre-loaded form.
- Most systems are Fletcher, Henschke or their modified versions and still use point A for dose prescription.
- Only one applicator system from Amersham follows closely the recommendations of the Manchester system but uses ^{137}Cs sources. For a standard insertion, tables were designed for this system for various combinations of vaginal and uterine applicators. Use of point A in this system is close to its modified definition in the Manchester system.
- For all other systems prescription to point A should be used with caution. For example, it was reported that the calculated dose contribution from the ovoid sources can be in error by as much as 25% unless correction is made for the different absorption of ^{137}Cs gamma rays in the Fletcher/Suit applicators designed for Radium (Godden, 1988).
- Caution also needs to be used when tables outlining mg-hrs and application times used for Fletcher system are used with other applicators, especially with those in which the source axis is along the vagina rather than at right angle to the intrauterine tube.

Computerized Dosimetry

- Applicators are reconstructed from radiographs or from CT data set. Applicator-based brachytherapy still requires prescription points based on the applicator position.
- Most institutions still use point A and B although their meaning and their definition may be interpreted in different ways. Applicator geometry affects the dose to the modified point A. Afterloading applicator's vaginal ovoids may not sit in the natural position for the ovoids, and may get pushed high, leaving point A in high dose gradient.
- Even though computerized dosimetry helps in eliminating reliance on the mg-hrs dose tables, but error in establishing the dose prescription point may lead to serious dose delivery problems.
- In image based brachytherapy, where dose prescription is according to the target volume, dose prescription to a point may not be relevant, but for inter-comparison purposes many institutions still use them.

Dwell Time Optimization

- High dose- rate remote afterloading systems use dwell time optimization, which may be useful in loading intracavitary applicator and vaginal ovoids optimally to deliver dose to either prescription points or to a target volume. In the intracavitary applications, with just three catheters and limited number of allowable dwell positions, dwell time optimization cannot be used to its full advantage. Nevertheless, dose to critical organs like bladder and rectum can be reduced in some situations. Manchester system's role in such situations is limited to second check and to ensure proper proportion of the source activities used in intrauterine catheter and vaginal ovoids.

Interstitial-intracavitary Implants

- Interstitial techniques are designed to deliver prescribed dose to the target volume, generally taken to be the volume enclosed by the implanted needles. In early days of the development of these techniques, the dose was however, prescribed and reported for point A.
- For interstitial implants, dose prescription to point A cannot be justified, because it may lie right on the loaded position of the needle. Also, only in those cases, where a tandem has been used, one may think of assigning point A using the modified Manchester system definition. Point A in such situations may be thought of lying perpendicular to the tandem (at a point 2 cm cephalad to the flange) and 2 cm from its axis. Also this point should be midway between the needles (which may not be possible sometimes) so as to avoid rapid dose gradients. In those situations where intrauterine tandem has not been used, point A definition becomes all the more difficult to apply. So, point A seems to be of no relevance in the case of interstitial- intracavitary implants.

ICRU 38 revision

ICRU 38 discouraged the use of point A and B because the exact meaning and their definitions have not always been interpreted in the same way in different centers and even in the same center over a period of time. The different methods of definition provide different values for the calculated dose rate to point A. Therefore, if the prescribed dose to point A is used to calculate the total time of application, different values of time will be obtained for different methods used to assign the prescription point. This report encourages the use of target volume for dose prescription and reporting along with the reference volume for 60Gy absorbed dose prescription. This report is being revised and may include some dose points similar to the classical systems. Details of the ICRU 38 revision are discussed elsewhere in the proceedings.

