TECHNICAL ASPECTS OF THE PRETORIA APPROACH TO THE USE OF RADIUM IN THE TREATMENT OF CANCER OF THE UTERUS

D. J. SAVAGE, M.Sc., and J. C. B. MILLIN, B.Sc.

Physics Section, Department of Radiotherapy, Pretoria General Hospital, Pretoria

The Pretoria method of radium treatment of cancer of the cervix and body of the uterus has been developed and refined over the past 4 - 5 years. Both the radiotherapy and the physics staff members have been involved in devising, trying out, criticizing and modifying the uterine radium applicators in order to produce a method which overcomes most of what we consider are the drawbacks of other systems.

Fichardt[1] presented a paper to the 1961 South African Medical Congress in which he described the Pretoria method of radium treatment of cancer of the cervix and gave details of 124 cases in which this method was used. Slight modifications have since been made to the design of the applicators, mainly to simplify the loading; a new method of radium treatment of cancer of the corpus uteri has also been devised.

In this paper we describe the construction of these applicators, the dosage distribution around them, and the radiation safety measures that are adopted when they are used.

I. THE APPLICATOR FOR TREATMENT OF CANCER OF THE CERVIX UTERI

The applicator consists of a uterine tube and a vaginal hemisphere. The uterine tube is separate from the hemisphere, but the two pieces may be joined, either before or after insertion, to form a unit. When joined the relative movement between uterine and vaginal radium is restricted and so the dosage distributions obtained will be close to those intended. This is the main advantage of this form of applicator over those where the vaginal and uterine portions remain separate and where packing or the tumour itself may cause unsatisfactory relative positioning of the components of the applicator.

The vaginal applicator consists of a PVC hemisphere 5 cm. in diameter. The inside of the hemisphere is partly hollowed out and there is a hole 8 mm. in diameter in its centre. The uterine applicator is a PVC tube 8·5 mm. in diameter and 9 cm. in length. One end of the tube is closed except for a pinhole, and has a blunt point. Radium extends 4 cm. down from the closed end. The uterine tube is inserted into the hole in the hemisphere so that 5 cm. of it protrudes. The tube may be inserted into either side of the hemisphere so that the assembled applicator resembles either a mushroom or a funnel. The choice depends upon the form of the tumour, i.e. whether it is a fungating mass or an ulcerative cavity. A certain amount of dilation of the uterine canal is normally required before the uterine

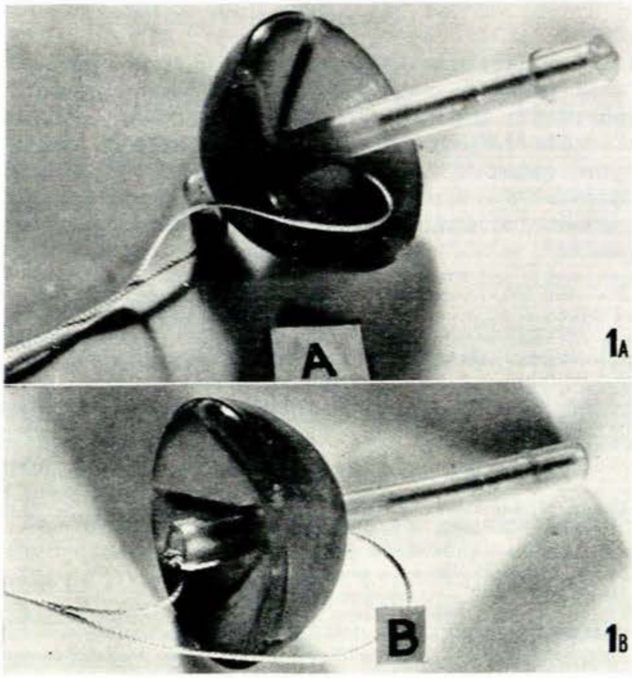

Fig. 1. A. Mushroom-shaped cervical uterine applicator. B. Funnel-shaped cervical uterine applicator.

tube can be inserted. Fig. 1 shows the applicator in its two forms.

Radium Capacity of the Applicator

Five 10-mg. tubes are inserted into holes drilled into the hemisphere and two 20-mg. tubes are placed in tandem in the upper 4 cm. of the uterine tube. In the event of 20-mg. tubes not being available, then uterine tubes with parallel longitudinal holes are cast and two 10-mg. tubes are used in place of each 20-mg. tube.

Dosage Distribution around the Applicator

Isodose curves were obtained by the summation of contributions from each tube at a number of points. Tables have been published[2] giving the dose rates resulting from the various forms of radium tubes in terms of the distances from and along the axes of the tubes. These distances were calculated geometrically for this applicator.

The dosage distributions resulting from a 72-hour exposure with radium tubes having 0·5 mm. of platinum filtration and active length 13·5 mm. are shown in Fig. 2. The dose rate at point A is 84·2r/hr. or 6,060r in 72 hours. At point B the dose rate is 22·5r/hr. or 1,620r in 72 hours. When tubes of filtration 1·0 mm. Pt and the same active length are used, the dose rate at point A is 77·1r/hr. and the exposure time must be increased to 78·5 hours for equivalent dosage.

There is not a great deal of difference between the dosage distribution resulting from the two methods of joining the applicators and the same treatment time is used for both.

The dosage distribution is very similar to that resulting from the accepted methods of radium treatment of the cervix. This is to be expected as radium can be placed only in

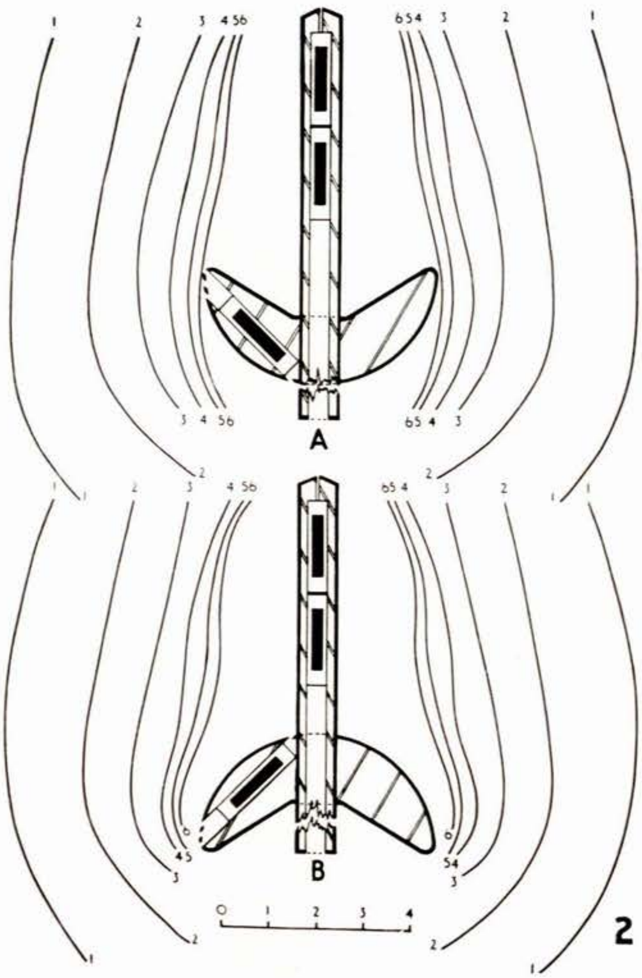

Fig. 2. Dosage distribution in kiloroentgens resulting from 72 hours' exposure using radium filtered by 0·5 mm. of platinum. The scale is in centimetres.

the vagina and in the uterus. The larger the applicator the greater the exposure in milligram-hours that may be administered without raising the local dose (point A, bladder, rectum) beyond tolerable levels. The dosage received by points 5 cm. or more lateral to the cervix will depend only on the exposure in milligram-hours and not on the shape of the applicator. The size of the applicator is limited by the size of the patient. In the Manchester system as described by Meredith[3] and a subsequent modification described by Tod and Meredith,[4] and the Stockholm system as described by Kottmeier,[5] allowance for this is made by using applicators of various sizes in which different quantities of radium are used. In the smallest Manchester size 80 mg. are used and in the largest size 150 mg. When a dosage of 6,000r at point A is given the dosage at point B will be 1,300r and 2,460r respectively when these two sizes of applicators are used. In the Stockholm technique the radium content of both uterine tubes and vaginal applicators is varied; in addition various exposure times are used. In fact to undertake this treatment successfully would appear to be more of an art than a science. It is apparent that there is as much variation between modifications in one system as there is between different systems.

The points that the different systems and variations have in common are the following:

(*a*) The dose to bladder or rectum is not allowed to exceed 6,000r.

(*b*) The dose to point A is between 6,000 and 8,000r.

(*c*) The dosage to the cervix and interior of the uterus is much higher than that at point A (up to about 30,000r).

(*d*) Uterine and vaginal radium contributions to point A are similar.

These points apply to the Pretoria applicator possibly more strictly than to other systems because the uterine tube is firmly attached to the vaginal hemisphere. We therefore regard the Pretoria method not as a new form of irradiation, but merely as a new technique of administering a dosage of radiation that has already been proved by other techniques to be the most satisfactory for the treatment of carcinoma of the cervix.

Treatment Policy

One radium application of 72 hours is given, and this is followed by supplementary X-irradiation of the parametria one week after completion of the radium treatment. The Paterson[6] 8-field technique is used for the X-irradiation. Should the patient be too large to benefit from the X-irradiation (antero-posterior diameter greater than 20 cm.) a similar treatment is carried out with telecobalt radiation, 3,600r tumour dose being administered in 3 weeks.

Should the patient, owing to anatomical or other considerations, be regarded as unsuitable for this type of applicator, no modification is made, but the patient is treated by 3- or 4-field telecobalt irradiation instead, with a field size of 12×10 cm. at the tumour and a tumour dosage of 5,400r in 4 weeks.

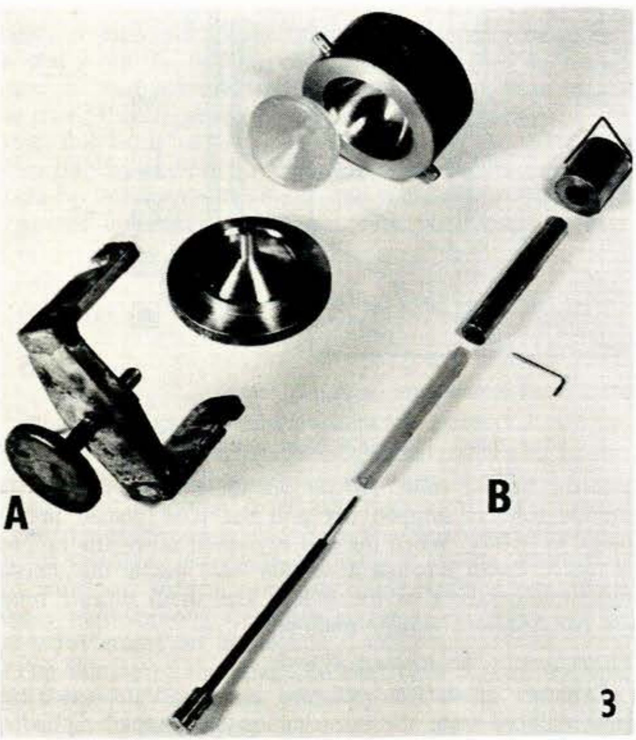

Fig. 3. A. Mould for casting vaginal hemisphere. B. Mould for casting uterine tube.

Construction of the Applicators

The present form of applicator has been evolved by trial and error with different designs and materials. The applicators are made of 'Welvic' PVC paste, grade ME 9/5, made by Imperial Chemical Industries, Ltd., which is baked in suitable moulds constructed of brass and mild steel (Fig. 3A and 3B). The moulds are filled with the paste, clamped together, and baked for ¾ to 1½ hours at 150°C. to set the plastic. The uterine tubes require less baking than the hemispheres owing to their smaller size.

II. APPLICATORS FOR CANCER OF THE CORPUS UTERI

The uterus is packed with radium tubes in a way similar to the Stockholm method.[5] The same uterine tube as that used for the cervix is used. This is loaded with three 20-mg. radium tubes instead of two. In addition to this tube, four smaller tubes are used, each containing 10 mg.

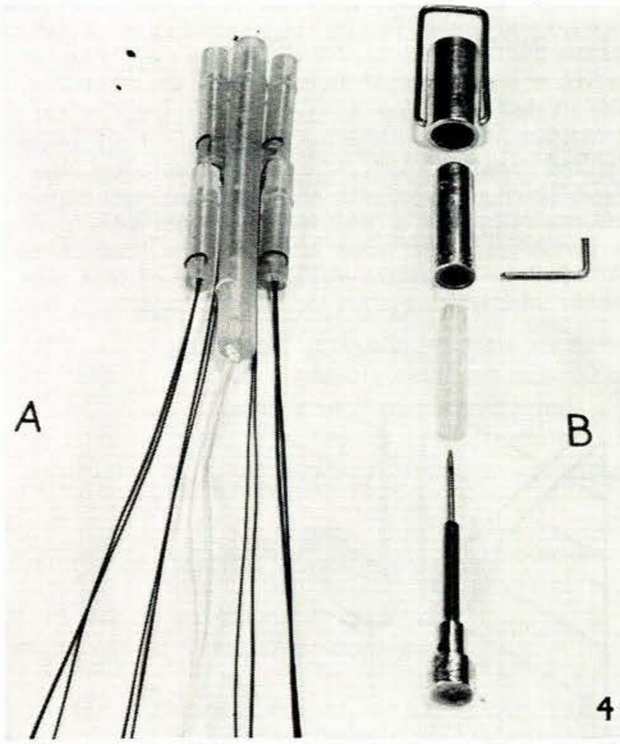

Fig. 4. A. Applicators used for treatment of cancer of the corpus uteri shown in ideal relative positions. B. Mould for casting smaller uterine tube.

of radium. These tubes are 6·5 mm. in diameter and 30 mm. in length. When a 2-cm. radium tube is in position in the tube, about 7 mm. of the tube is unfilled. A suitable rod may be pushed into this cavity and then used to insert the applicator into the uterus. Once in position the rod may be withdrawn.

The four small tubes are inserted into the uterus first, followed by the long uterine tube. The ideal distribution is as shown in Fig. 4A. As the position in the large tube of 60% of the radium is fixed, variation in the position of the remaining 40% (i.e. the four small tubes) will not seriously affect the dosage distribution.

The dose rate 2 cm. laterally from the midline of the uterus is about 121r/hr. or 8,700r in 72 hours when radium tubes filtered by 1 mm. Pt are used.

The small applicators are made in the same way with a mould (Fig. 4B).

Before loading, thick surgical silk is attached by means of a needle to the open end of both small and large uterine tubes (Fig. 4B). As the large uterine tube must be removed first, it should be threaded with silk of a different colour from the other tubes.

III. PROTECTIVE DEVICES USED IN THE RADIUM LOADING ROOM AND WARDS

The radium bench is a thick slab of concrete having a height of 45 inches. Storage pits 6 inches in diameter and 18 inches deep are situated 28 inches from its front face. These pits have lids backed with lead 1 inch thick which are attached to counterweights so that they are easily opened and closed. Baskets are attached to the undersides of the lids, in which loaded applicators may be stored in safety at the bottom of the pits, where the concrete gives the greatest protection.

When the operator is at the bench protection is afforded by lead slabs 17″×17″×3″ suspended on rollers from the roof. There are three such slabs and these may be placed either side by side or with spaces between them to allow a person's arms to reach around to the bench surface. Attached to the centre slab is a block of lead glass 4 inches thick which enables the work in hand to be viewed directly without over-exposure of the eyes. The bench top is divided into a 'dirty' side and a 'clean' side where the radium is unloaded and loaded respectively. Owing to the mobility of the centre lead slab, the lead glass may be used on either side. Mirrors, a sink with hot and cold water, and the usual handling tools are also provided on the radium bench.

Loading Jigs for Uterine Applicators

In order to protect the hands from excessive irradiation, jigs have been constructed in which the various applicators may be loaded and unloaded. The vaginal hemisphere is clamped in a hollow between two lead cylinders (originally an isotope container). Steel sleeves fitted into holes in the upper cylinder form guides through which the PVC hemispheres may be drilled, loaded with radium, and finally unloaded by pushing the radium tubes right through so that they fall through a hole in the base (Fig. 5).

The loading jig for the large uterine tube (Fig. 6) is simply a hole in a block of lead into which the tube is placed. A second block of lead into which a smaller hole is drilled fits over the lower block. Radium can be inserted into the upper block and with a suitable rod pushed into the uterine tube. To unload, the pointed end of the uterine tube is snipped off and the tube placed in the block as before. When the rod is pushed down the radium is forced down through a smaller hole below the uterine tube and falls out of the block. The small uterine tubes are handled in a similar manner.

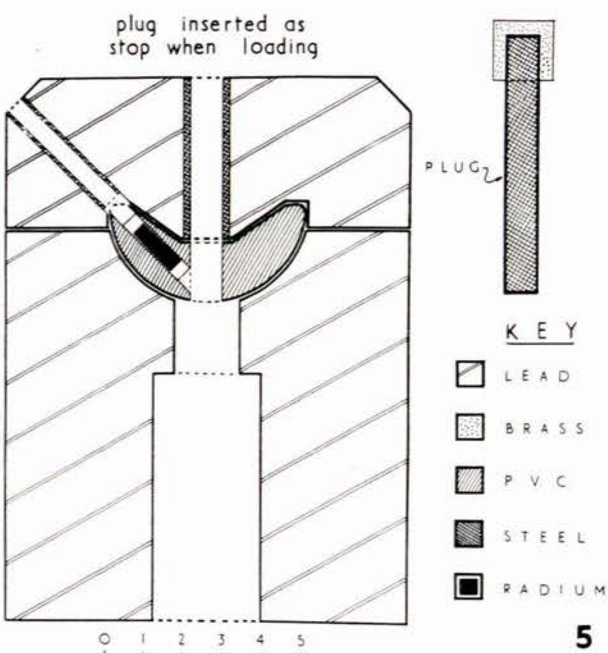

Fig. 5. Loading and unloading jig for vaginal hemisphere. The scale is in centimetres.

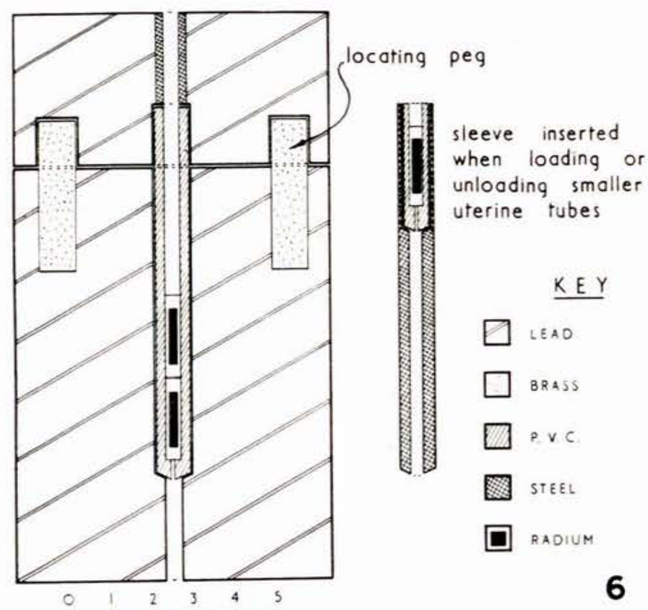

Fig. 6. Loading and unloading jig for large and small uterine tubes. The scale is in centimetres.

Protection in the Radium Wards

Exposure of staff to radiation in the radium wards has been reduced since the introduction of overbed tables incorporating lead shielding. The overbed table (Fig. 7) straddles the bed and stands on wheels on the floor. The construction is of steel tubing, and lead protection 1½ inch thick is attached to the upper portion of the sides and part of the top. The centre portion of the top con-

Fig. 7. Overbed table incorporating lead shielding.

sists of a glass plate which, while it provides a table top, also enables a certain amount of attention to be given to the patient from behind the lead screen. If a nurse stands at each side of the table, the table may be moved up and down the bed to provide protection for the nurses while the bed is made up. These tables have been in use for more than 2 years. Nurses new to the ward soon develop the habit of making maximum use of the tables when nursing radium patients. Fig. 8 shows the difference made by this overbed table to the radiation levels around a patient undergoing treatment with 90 mg. of radium.

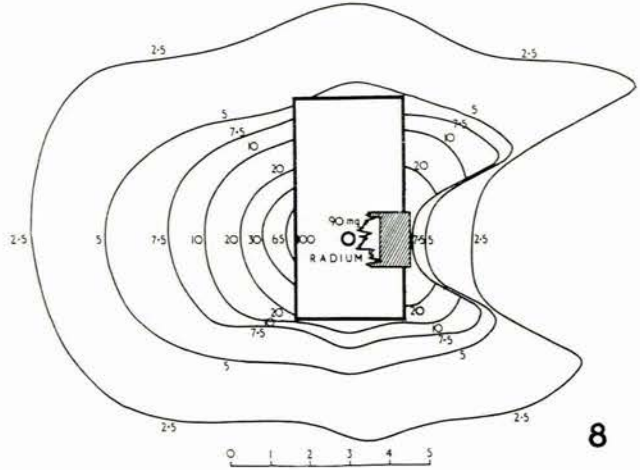

Fig. 8. Dosage distribution in milliroentgens per hour around patient undergoing treatment with 90 mg. of radium. Left side no shielding. Right side with overbed table. The scale is in feet.

The isodose curves were measured at waist height above the floor.

Our thanks are due to Prof. T. Fichardt, Head of the Department of Radiotherapy, for his assistance and permission to publish this article, and to Mr. Theo Marais, Chief Clinical Photographer, for the photographs. We also wish to acknowledge the contributions made by Dr. C. L. Jacobs, Dr. C. R. Jansen, Dr. A. G. Sandison, Dr. J. V. van Zyl and Mr. P. C. Minnaar in the development of these applicators.

REFERENCES

1. Fichardt, T. (1962): S. Afr. Med. J., **36**, 303.
2. Hospital Physicists' Association (1954): *Diagrams and Data, Scheme Catalogue D.* London: Hospital Physicists' Association.
3. Meredith, W. J. (1947): *Radium Dosage: The Manchester System,* p. 39. Edinburgh: Livingstone.
4. Tod, M. C. and Meredith, W. J. (1953): Brit. J. Radiol., **26**, 252.
5. Kottmeier, H. L. (1953): *The Abraham Flexner Lecture, No. 11.* Baltimore: Williams & Wilkins.
6. Paterson, R. (1948): *The Treatment of Malignant Disease by Radium and X-rays,* p. 354. London: Edward Arnold.