Rotation Technique for Superficial Total Body Electron Beam Irradiation

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Low megavoltage electrons, because of their limited penetration, have been found very useful in the treatment of generalized superficial malignancies. However, because of the complexity of the human body contour, it is extremely difficult to achieve uniform dose distribution over the entire body surface. To achieve this, various techniques ranging from two to six fields have been used. In this paper, we discuss the disadvantages of these techniques and describe a new technique, "the rotation technique," which is superior.

Total body irradiation with low megavoltage electrons has proven useful in the treatment of generalized superficial malignancies such as mycosis fungoides, Sézary syndrome and Kaposi sarcoma. Trump[1] and his associates, in 1953, for the first time successfully used low megavoltage electrons from a Van de Graff machine on patients with mycosis fungoides. Subsequently, many other investigators used low megavoltage electrons for total body irradiation. So far, two to six-field techniques have been used to achieve uniform dose distribution over the entire surface of the skin. The purpose of this paper is to describe the new rotation technique used by the authors for total body electron irradiation and discuss its advantages over the previously used two to six-field techniques.

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Materials and Methods

Cylindrical masonite phantom of 26 cm diameter and Rando-Alderson phantom were used to study the depth dose distribution curves, using four field, six field, and rotation techniques. The measurements were made with thermoluminescence dosimeters (TLD) placed along the radius of the phantom and film dosimetry. 6 MeV electrons from an 18 MeV linear accelerator after degrading to 3.2 MeV electrons by a 10 mm plexiglass screen were used.[2] Figure 1 shows the depth dose curves of 6 MeV and degraded 3.2 MeV electrons. The degraded 3.2 MeV electrons depth dose curve shows that the surface dose is 87 percent, Dmax is at 2 mm, 80 percent dose is at 7 mm, and 50 percent dose is at 10 mm.

Figure 2 shows the composite depth dose distribution curves obtained in both the circular and Rando-Alderson phantoms using four fields separated at 90°. The reference point A received radiation from a direct field at 0° angle and from two fields on either site at 90° angles. The depth dose curve through point A shows the reduction in the skin-sparing effect of the low megavoltage electrons. This is because of the effect of the oblique rays from the two 90° fields reaching point A. At point B which is the mid point between two point As the dose is 40 percent more than the dose at point A because of overlap of the fields. When we used four-field technique, this high dose area along point B was clinically observed by longitudinal strips of severe skin reactions as shown in Figure 3. Even though the dose at point B is high, the overall depth dose is lower than that through point A because there is no beam entering point B at 0°, but the beams from the adjacent fields enter point B at 45°.

Depth dose distribution curves for six fields separated at 60° are shown in Figure 4. Here the reference point A received radiation from a direct field at 0° and two fields at 60°. The depth dose

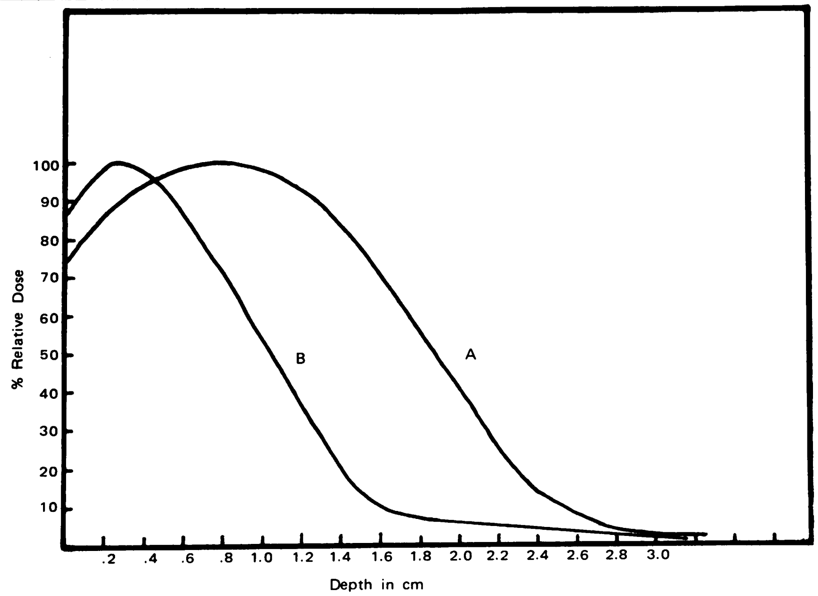

Figure 1. Curve A is the depth dose curve of 6 MeV electrons at 3 meters. Curve B is the depth dose curve of 3.2 MeV electrons at the same distance.

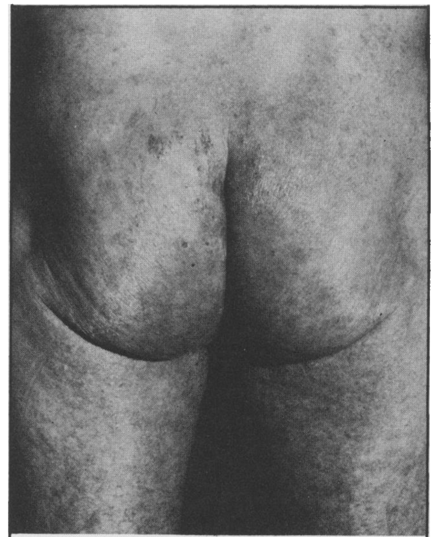

Figure 3. The longitudinal strips of depigmented areas along the para vertebral areas are due to severe skin reaction corresponding to point B in the four-field technique.

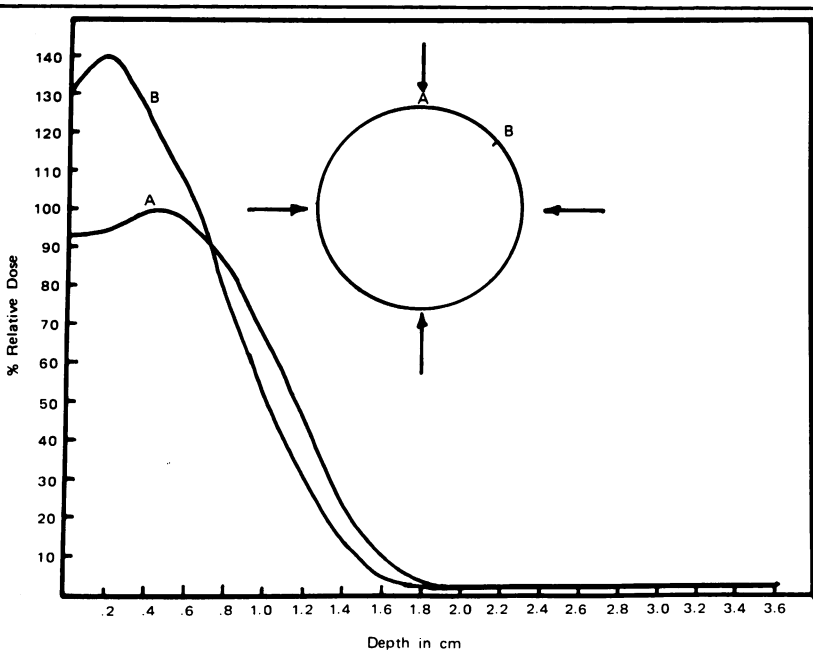

Figure 2. Curve A is the depth dose curve through point A where the 3.2 MeV electron beam enter at 0° angle. Curve B is the depth dose curve through point B where the beam enters at 45° angle.

curve through point A shows complete absence of the skin-sparing effect of the low megavoltage electrons. The inhomogeneity of the dose has been decreased with a maximum variation of about 12 percent between points A and B. Here point B gets 12 percent less than that at point A unlike in the four-field technique where point B gets 40 percent more than point A. In the six-field technique, the beams from adjacent fields enter point B at 30°, therefore the depth dose curves through point A and B coincide below 10 mm, unlike in the four-field technique, where the overall depth dose through point B is lower than that through point A. In this technique the overall depth dose, both through points A and B, is lower than that through point A in the four-field technique because of the increased component of the oblique rays.

Results

From the above studies, it is clear that the dose through point A, that is the point of incidence, and point B, that is the mid point between two point As, varies from 40 percent in four-field technique to 12 percent in six-field technique. In addition, the overall depth dose through point B in four-field technique is lower than the depth dose through point A because the angle of incidence at point B is 45°. In addition to the unequal dose distribution through points A and B in the four and six-field techniques, these techniques are time consuming, because the treatment has to be stopped after treating each field and the new field has to be set up.

In the rotation technique the phantom is placed on a rotation platform which rotates at a speed of 5 rpm. Since the phantom rotates throughout the treatment, every point along the surface receives radiation ranging from 0 to 90° and there are no points A and B. The composite depth dose curve for rotation technique is shown in Figure 5. Here, once again, the overall depth dose is lower than that through point A in the four-field technique, because of the increased component of the oblique rays. The skin-sparing effect also is absent in this technique for the same reason. The depth dose in the rotation technique can be improved by using a

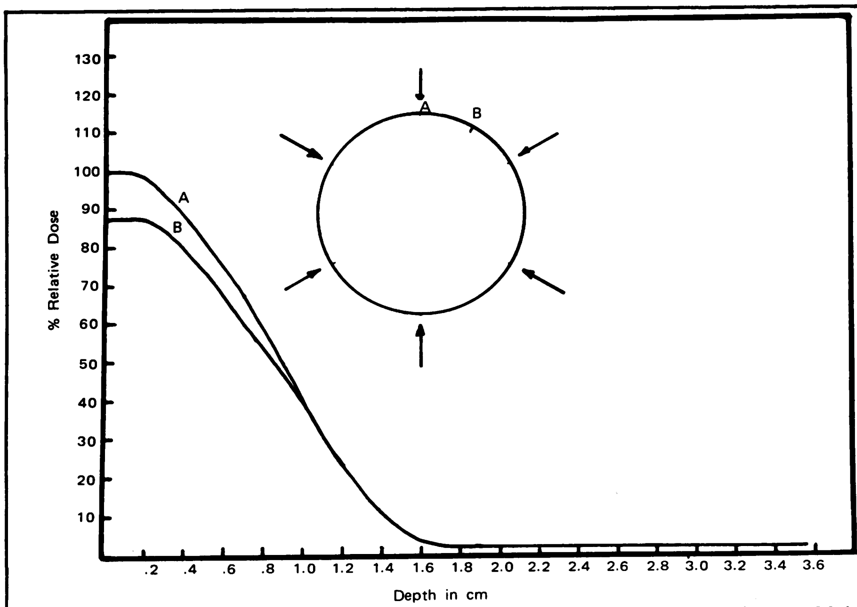

Figure 4. Curve A is the depth dose curve through point A where the 3.2 MeV electron beam enters at 0° angle. Curve B is the depth dose curve through point B where the beam enters at 30° angle.

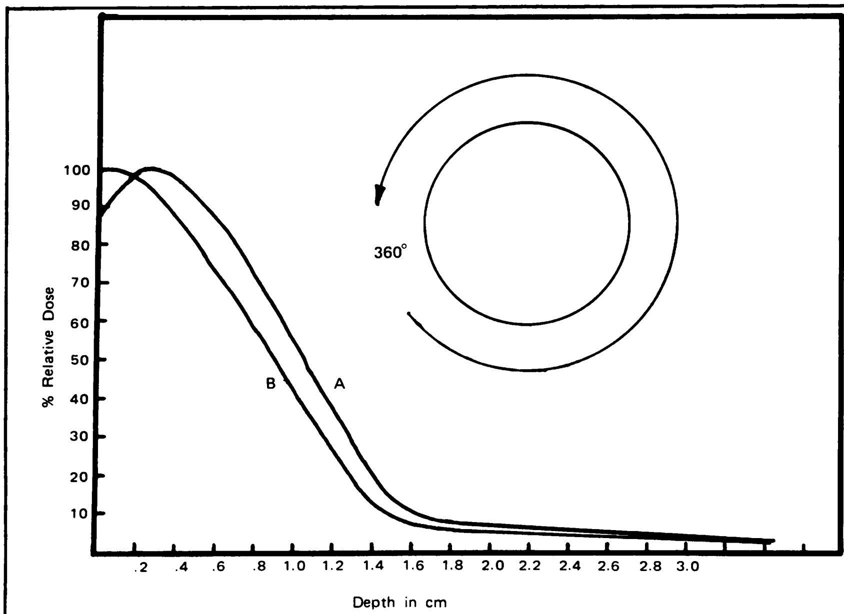

Figure 5. Curve A is the single field depth dose curve of 3.2 MeV electrons. Curve B is the composite depth dose curve obtained with rotation technique. In curve B there is complete absence of the skin-sparing effect and the overall depth is lower than that of curve A.

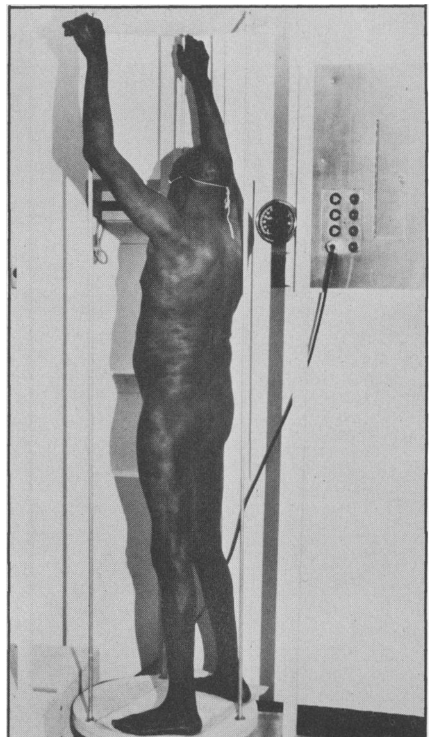
Figure 6. Shows the treatment set up for total body electron beam irradiation using rotation technique.

narrow beam which eliminates the oblique rays component. The actual patient set up on a rotating platform is shown in Figure 6.

Discussion and Conclusions

Low megavoltage electrons are very useful in treating generalized superficial malignant diseases such as mycosis fungoides, Sézary syndrome, and Kaposi's sarcoma because of their limited penetration. However, one of the major problems in superficial total body electron beam irradiation is achieving uniform dose distribution. Two to six-field techniques have been used for this purpose previously. These multiple-field techniques are time consuming and do not solve the problem of achieving uniform dose distribution as shown in this paper.

In the phantom, the uniformity in dose distribution can be improved by using eight or 12 fields. However, in a patient, this is not practical because of the constant motion of the patient. Therefore, we adopted the rotation technique for the superficial total body electron irradiation which not only gives satisfactory dose distribution, but also cuts down the treatment time. This technique, however, does not solve the problem of under dosage to certain areas from self shielding. As we have reported previously,[3] the vertex of the head, undersurface of the pendulous breast, ventral surface of the penis, the perineum, and the soles of the feet will have to be boosted separately to achieve uniform dose distribution over the entire skin surface. Shielding of the eyes and nails is incorporated in the preparation of the patient for the therapy.

Literature Cited

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