WHOLE BODY ELECTRON THERAPY USING THE PHILIPS SL75/10 LINEAR ACCELERATOR.

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Whole body electron irradiation is frequently used in the treatment of mycosis fungoides, a disease which may involve large areas of the body surface. The major technological problems encountered in whole body electron therapy (WBET) are as follows:

1. Delivery of a radiation dose to a layer 10-15 mm deep uniformly over all of the patient's body.
2. Minimizing contamination of the beam by Bremsstrahlung X-rays generated in electron interactions with matter located between the electron source and the patient.
3. Achievement of a practical treatment session time, taking into account limitations on the maximum dose rate available and on the maximum dimensions of the treatment beam.

In the most common method of WBET, patients are irradiated by beams of 3-4 MeV electrons while standing at a distance of 3-7 meters from the electron source to produce large treatment fields (1,2). An electron scattering layer is needed to achieve satisfactory dose uniformity. Since the beam intensity decreases because of the inverse square law while, at the same time, the X-ray/electron dose ratio is enhanced by preferential attenuation of electrons in the scattering layer and in air, this method requires an accelerator with a high electron output together with a low intrinsic level of X-ray contamination.

At a distance of 3 meters, the maximum intensity of the standard 4 MeV electron beam from our Philips SL75/10 linac is only about 10 rad/min when a 3 mm Perspex scattering plate is present while the X-ray contamination increases from a tolerable value below 2% at 1 meter to about 8%. These conditions are not acceptable, hence a long distance method is not suitable for our machine.

An alternative procedure is to treat the patient at a shorter distance with an electron beam that scans the surface of his body. For example at Manchester a scanning system has been constructed for the SL75/10 linac in which a moving platform replaces the usual treatment couch (3). This approach was rejected because it was felt that the adopted method should introduce minimum changes in the routine of an already busy treatment machine.

In this paper we describe the method used at our center for WBET which was developed under the constraint that no special equipment or modifications to the linac should be required.

MATERIALS AND METHODS

Treatment was performed with an electron beam of nominal energy 4 Mev from the Philips SL75/10 linac. No electron applicator was attached and no scattering layers were present except for the beam exit window, the monitor ionization chamber and the air space between the linac and the patient. During irradiation the patient reclined on the regular treatment couch at a source-to-skin distance of 150 cm. The collimator was fully open.

Measurements of the depth dose properties of the electron beam were made with the aid of thin polystyrene sheets and a parallel plate ionization chamber (S.H.M. build-up chamber) connected to an electrometer (Keithley Model 600B). The ionization chamber was calibrated against a Cobalt-60 source using the method recommended by the H.P.A. (4). Dose distributions in a Rando Phantom were determined by means of thermoluminescent detectors (Harshaw TLD-100) and X-ray film (Kodak Type XV-2). Dosage to patients was monitored by taping TLD detectors to the skin.

RESULTS

Properties of the radiation beam

To achieve the clinically desired penetration, the energy of the electron beam was adjusted so that the 80% depth dose occurred at a depth of 13 mm. Fig. 1 shows the behavior of the central axis depth dose of the beam used for whole body treatment. At a depth of 5 cm the ratio of the X-ray dose to the peak electron dose is 1.7%. Fig. 2 shows profiles of the electron beam and its X-ray component. Both beams are approximately gaussian in shape with a F.W.H.M. of 50 cm.

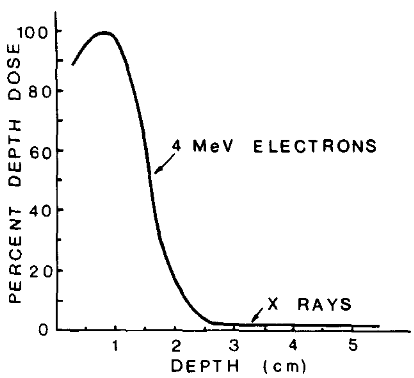

Fig. 1: Central axis depth dose of the treatment beam.

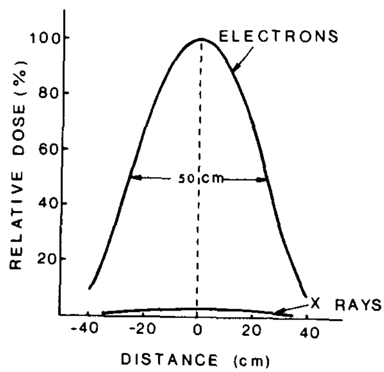

Fig. 2: Profile of the treatment beam.

Treatment technique

To cover the entire surface of the patient's body it is necessary to apply multiple fields. Because of the gaussian nature of the beam the matching of adjacent fields is not critical. Fig. 3 shows how a uniform dose is produced over a large cross section when 2 beams are joined at the 50% value of the profiles. An error of 1 cm in the separation distance causes an overdosage or underdosage of only 5%.

The patient lies in prone and supine positions during treatment. In each case a pair of fields is needed to include the width of the body and 5 pairs are used to produce uniformity over a patient up to 200 cm tall.

If the beam axes are perpendicular to the plane of the treatment couch, at the lateral edges of the body the radiation will intercept the body cross section at tangential incidence. This leads to regions of underdosage at the body edges (3). To overcome this problem, the gantry was rotated through a small angle to shift the points of tangential incidence away from the midplane. The same angle (20^o) was used for the anterior and posterior fields. The beams incident on a typical body cross section are shown in Fig. 4.

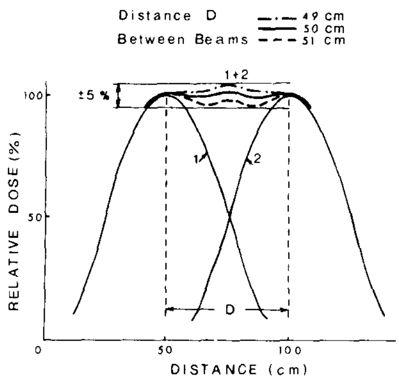

Fig. 3: Resultant profile when 2 beams are joined.

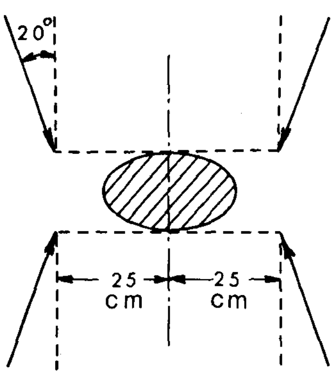

Fig. 4: Beams incident on a body cross section.

TLD and film measurements made with the Rando Phantom indicated that variations in the peak electron dose are within ±15% over the entire body except for the groin, axillae and soles of the feet which are shielded by other parts of the body. The depth of the peak dose depends on the angle of incidence. Fig. 5 shows a film representation of the dose distribution in the phantom when exposed to the set of WBET beams.

Treatment is given in 4 fractions per week. One quarter of the body surface is irradiated to 400 rads at each session. The dose rate at the patient is 100 rad/min. and the time for each treatment session is about 30 minutes. The groin, axillae and soles of the feet are treated separately by small electron fields to compensate for under dosage during the whole body irradiation. The eyes, fingernails and toenails are protected by lead shields during treatment.

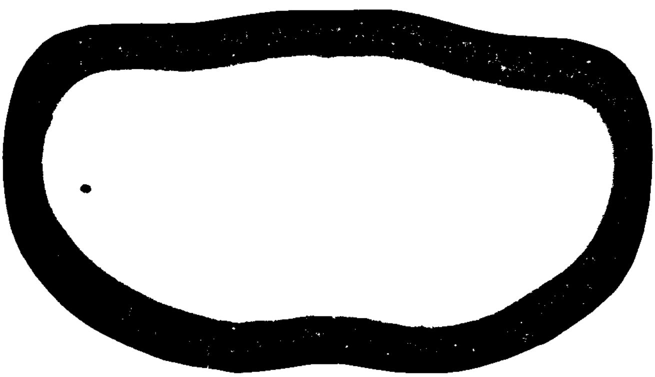

Fig. 5: WBET dose distribution in the Rando Phantom as recorded on X-ray film.

CONCLUSION

Our technique provides a practical solution to the clinical requirements for WBET with respect to uniformity of electron dose and low X-ray contamination. Its implementation doesn't require special equipment or modifications to the linac.

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