PROCEEDINGS OF III rd SEMINAR ON TREATMENT PLANNING IN RADIOTHERAPY IN POZNAŃ

TOTAL SKIN ELECTRON IRRADIATION

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INTRODUCTION

Total skin electron irradiation (TSEI) remains one of the most effective modes of treatment for skin lesions covering large areas of the body, such as mycosis fungoides [Spittle 1977, Fuks et al 1977, Heppe et al 1979, Van Vloten et al 1985, Le Bourgeois et al 1987, Jones et al 1994, Becker et al 1995]. Prior to the use of low energy electron beams, X-rays of 55-70 kV were used [Le Bourgeois et al 1977], but they gave less encouraging results. They did not make it possible to treat homogeneously the whole skin surface, and yielded a larger X-ray integral dose. Low energy electron beams are preferrable because they show a rapid fall-off of the dose with depth and permit homogeneous treatment of the whole skin, associated with a very low X-ray background.

After a brief review of different Total Skin Electron Irradiation (TSEI) techniques described in the literature, we will present a technique developed at the Henri Mondor, hospital which can be implemented on any linear accelerator delivering 8-9 MeV electron beams. Important dosimetric problems encountered either when obtaining data or performing *in vivo* patient's dosimetry are also considered.

I - IRRADIATION REQUIREMENTS

It has been now well demonstrated that only patients in the early phase of the disease with very superficial lesions, involving less than 3-4 mm of tissue beneath skin surface, may have long term benefit of TSEI. The whole surface of the body must be homogeneously irradiated. This implies:
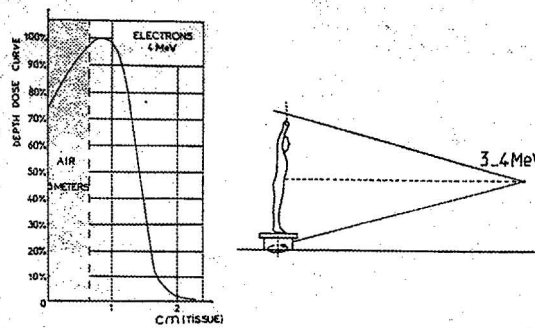• use of 3-4 MeV electron energy at the patient's level.

Figure 1. A large thickness of air separating 3-4 MeV electron source and patient interacts as a bolus and increases the entrance dose.

• treatment at large source skin distance (SSD) to cover the totality of the patient and to increase the entrance dose (Figure 1). If the distance is not large enough, a screen must be placed in front of the patient. When the treatment room is not large enough to treat the patient at a large distance from the source, multiple adjacent fields, patient's translation [Williams et al. 1979] and a multiple field pendulum arc technique (Figure 2) may be used.
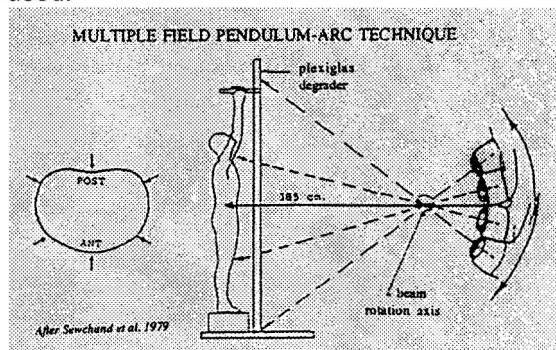

Figure 2. Multiple field pendulum arc technique [Sewchand et al 1979].

• compensation of the dose variations due to anatomical curvatures or thicknesses. It is well known that electron beams yield underdosages when their axis is not perpendicular to the

patient's skin [Holt and Perry 1982, Ritenour et al 1983, Podgorsak et al 1983, AAPM 1987]. In order to compensate for them, many authors have suggested the use of multiple large overlapping fields (6 to 8 in number) with change in the patient's position for each field (Figure 3).
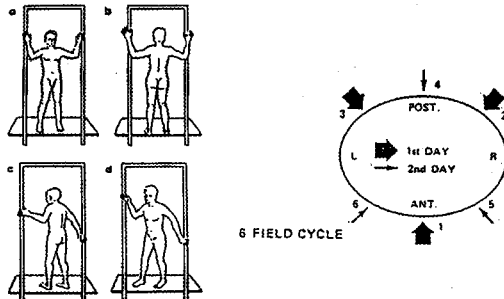

Figure 3. Example of a rotational technique as described in AAPM Report N° 23 (1985). The original technique was suggested by Karzmark en 1960.

• X-ray integral dose within the patient must be as low as possible (< 1% of the prescribed dose).

• dose-rate at the patient's level must be reasonable in order to avoid patient's movements and improve his comfort.

Many techniques described in the literature try to meat the above specifications. Since none of them has been found practicable in our hospital, because of the small size of our treatment room and the fact that no 3-4 MeV electron beam was available at our medical accelerator; we have developed a new technique. It has been used in our hospital and at other European centers since 1976.

II - HENRI MONDOR HOSPITAL TECHNIQUE

The technique consists of 3 vertical adjacent fields with the patient lying alternatively in prone and supine positions (Figure 4).
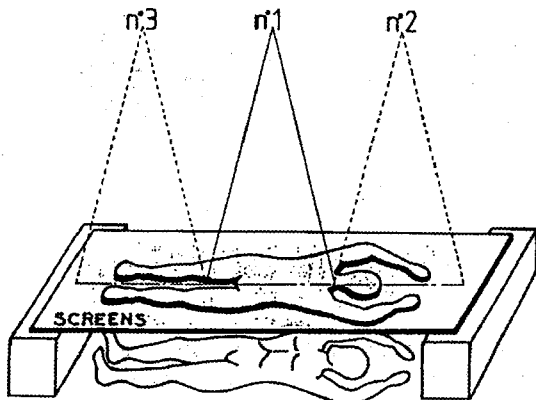

Figure 4. TSEI - Henri Mondor Hospital Technique

A composite lucite screen (1,5 cm thick in the center and 0,5 cm at the sides) is used together with an incident electron beam of 8-9 MeV. Because of the different thicknesses of the screen, the energy of the incident beam is more important at the sides than at the center, and thus, the penetration of the beams is improved in the lateral parts of the patient (Figure 5).
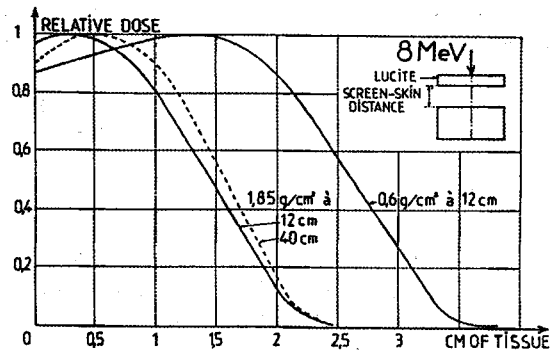

Figure 5. Depth dose curves corresponding to different screen thicknesses and screen-skin distances (12 and 40 cm).

A judicious cutting of the thickest screen adapted to patient's shape (Figure 6) yields a homogeneous dose distribution in any of the patient's areas of a large radius of curvature. For a detailed description of the dosimetric aspects of the technique and its application, the reader is referred to [Marinello et al. 1977] or [Marinello and Le Bourgeois 1992].
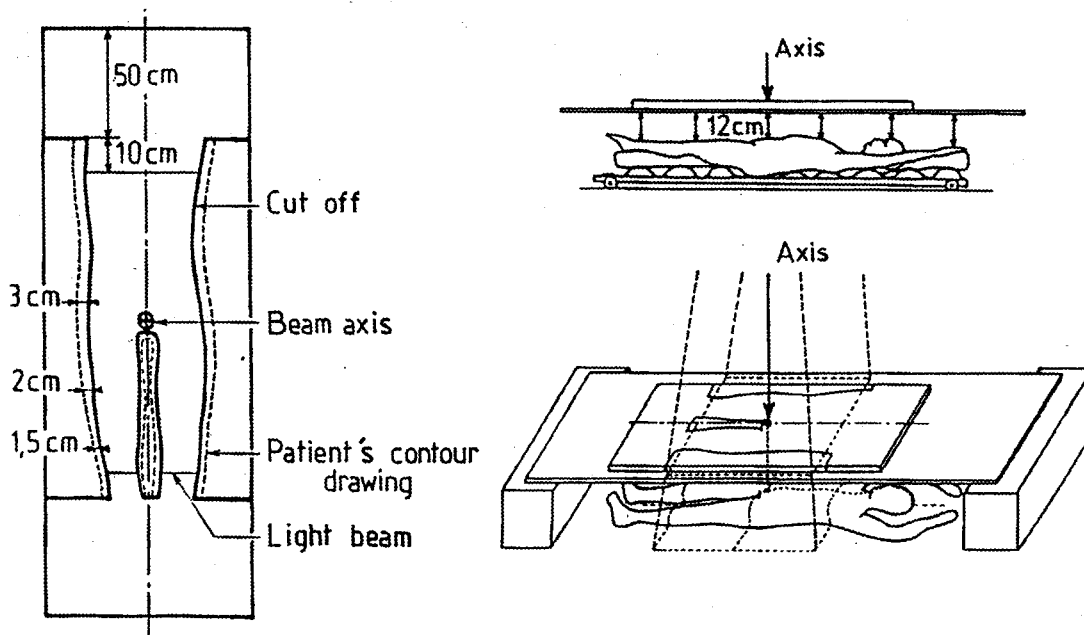
Figure 6. Screen adapted to the patient's shape: cutting [A] and positioning [B].[Marinello and Le Bourgeois 1992].

III - DOSE DISTRIBUTION IN BODY AREAS OF SMALL DIMENSIONS.

The dosimetric study performed essentially with TLD dosimeters and films has shown that the lucite screens were the best choice because their transparency makes the patient's positioning easier. Moreover, it results in a very low X-ray contamination.

It has also been shown that the screen has to be placed close to the patient both to increase the skin dose and to keep an acceptable dose-rate at the patient's level (0.3 - 0.5 Gy/min for usual dose-rates of 200 monitor units/min and 1.5 - 2.5 Gy/min, when an optional doserate of 1000 M.U./min is available on the linac).

Irrespective of the technique used, many authors [Spittle 1977, Horiot 1980, Frass 1983, Salomon et al 1984, Van Vlotel et al 1985, Desai et al 1988, Le Bourgeois et al 1990] have mentioned complications, such as extremity edema, blister formations, tenderness of hands and feet, nail distrophy, etc for TSEI. In order to explain them we have undertaken experiments with layered flat phantoms of small thickenesses and cylindrical phantoms (radii varying from 1 to 9 cm) simulating hand and lower limb cross sections. The results obtained at 4 MeV (mean energy at the patient's surface) have shown that the overdosage in the anatomical structure of a large radius of curvature, but small thickness (palm of hands), is 200 % of the prescribed dose for 1 cm thickness and 160 % for 2 cm. Doses become normal for thicknesses $\geq$ 3 cm

(Figure 7). Large variations of the dose have also been measured in cylindrical phantoms simulating fingers, ankles or the wrist. They depend on both the radius of the structure and the incidence angle of the beam at the skin surface.
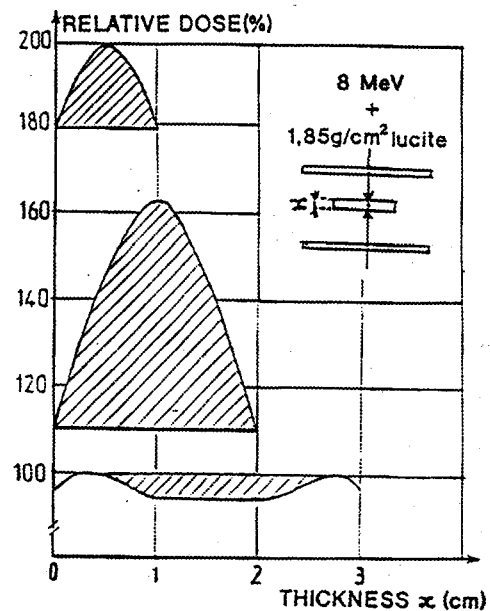

Figure 7. Dose distribution in human structures of 1.2 and 3 cm thicknesses. [Jaffré et al 1990].

Such results confirmed by *in vivo* measurements [Marinello et al 1980, Jaffré et al 1990, Jaffré et al 1994] can explain the complications in the anatomical regions of small radii of curvature and/or small thickness

(erythematous skin, swelling of feet, ankles and hands) reported by different authors. This is the reason why shields for the hands or feet have to be provided well before the full course of therapy is completed, irrespective of the irradiation technique used.

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