

METHOD OF DOSE PLANNING ON APPLICATION OF SHIELDING FILTERS IN COBALT 60 TELETHERAPY

by

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It is often desirable in radiotherapy to protect tissue enclosed within a volume which is to be given a high dose. The reason may be that the tissue has previously been heavily irradiated or that it is very radiosensitive. Protection against irradiation of tissues can be achieved by inserting absorbers in suitable places in the beam.

A method of protection has been described by *TRANter* (1959) and *Taylor* (1963), who used it in the supplementary radiation treatment of the parametria in cases in which the vagina and uterus had already been irradiated by radium sources. *Lederman* (1957) has reported on the protection of the lense of the eye in the radiation treatment of orbital tumours. Application of shielding filters in moving-beam therapy has been described by *Takahashi et coll.* (1961) and by *Proimos* (1963).

It is of course theoretically possible to work out isodose charts for different combinations of source-surface distances, field sizes, absorbers and their position in the beam, but this in practice would involve an excessive amount of

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work. By representing the effect of the different absorbers with 'subtractive isodose charts', according to the method described below, only one measurement needs to be performed with each absorber in an optional beam at each source-surface distance.

Principle of the method. In order to describe the simple principle on which this method is based, all the rays which reach the patient are assumed to come directly from the radiation source. A shielding filter (absorber), inserted into any beam, would on this assumption modify the radiation intensity over the cross-section of the beam in a way depending only on the effective attenuation of the filter. This, in turn, would of course have for effect that the dose rate at an arbitrary point within the irradiated object is reduced by a value which is independent of the size and shape of the beam. Consequently, the reduction in dose rate in a given plane can be represented by a 'subtractive isodose chart'. This negative isodose chart, standardized in a suitable way, can on dose planning be added to the standard isodose chart for the particular beam chosen, by means of which the dose distribution with shielding filter inserted may be obtained.

However, not all the radiation that reaches the patient comes directly from the source; about 12% constitutes scatter-radiation from the head of the treatment unit (CORMACK & JOHNS 1958). This means that the field size and the position of the shielding filter in the beam may influence the effect of the filter and consequently the subtractive isodose chart. Measurements have been made in order to establish the magnitude of error in the practical use of such standardized subtractive isodose charts. The measurements are reported below.

Testing of the method

The Eldorado Super G unit at Radiumhemmet (HULTBERG et coll. 1962) was used. This unit is provided with a block diaphragm, the front of which is situated 35 cm from the source; the source has a diameter of 2 cm.

The dose measurements were performed in a water-filled perspex container (30 × 30 × 40 cm), with an ionization chamber (BENNER et coll. 1959) having an external diameter of 4.5 mm and a length of 15 mm. The ionization current was amplified by a vibrating-reed electrometer. The wave-length dependence of the chamber is within $\pm 10\%$ at radiation qualities corresponding to the interval between HVL 0.1 mm Cu (100 kV, 1 mm Al) and HVL 14.7 mm Cu (cobalt 60). The chamber is connected with an automatic isodose recorder (LARSSON et coll. 1963).

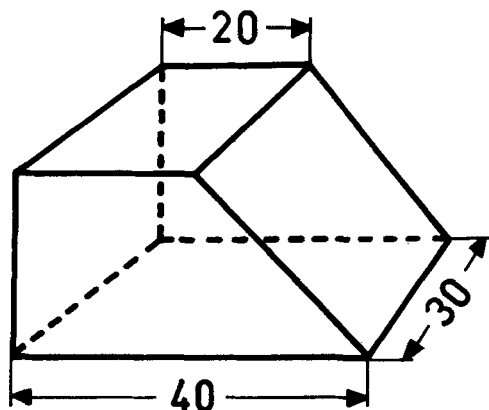


Fig. 1. The dimensions (in mm) of the shielding filter used in the investigation.

A shielding filter of lead suited to the purpose was prepared, the shape and dimensions of which are shown in Fig. 1. It was placed on a perspex sheet, 5 mm thick, at a distance of 60 cm from the source, with its plane of symmetry in the principal plane of the beam. The latter is defined as the plane containing the beam axis and being parallel to two of the sides of the rectangular fields. The source-surface distance was constantly 80 cm.

The dose measurements were for practical reasons limited to a few points in the phantom. These points were chosen so as to be situated in the principal plane, both along the beam axis, at depths of 2 cm and 20 cm, and along a line perpendicular to the beam axis at a depth of 10 cm. The dose was measured along the latter line at intervals of 1 cm, within ± 10 cm from the beam axis.

The dose rates were measured at the different points, with field sizes of 8×8 cm, 12×12 cm, 16×16 cm, and 20×20 cm, with and without the shielding filter in the beam. The filter was placed as shown in Fig. 2. The diagram origin in this set-up coincides with the beam axis. The cross-section of the filter drawn in the figure has been projected to the depth of 10 cm. By subtracting one from the other of the two values obtained at one point, a measure of the decrease in the dose rate with the use of a shielding filter will be obtained.

It was found that the decrease at each one of the measurement points varied within $\pm 2\%$ for the different field sizes used, and, consequently, that the filter reduces the dose rate almost independently of the field size used. The curve in Fig. 2 was established by using the mean value of the reduction in dose rate obtained at the different points along the line at a depth of 10 cm. This curve shows the reduction in dose rate, in percentage of the dose rate at a depth of 0.5 cm, with a field size of 12×12 cm, as a function of the distance to the beam axis.

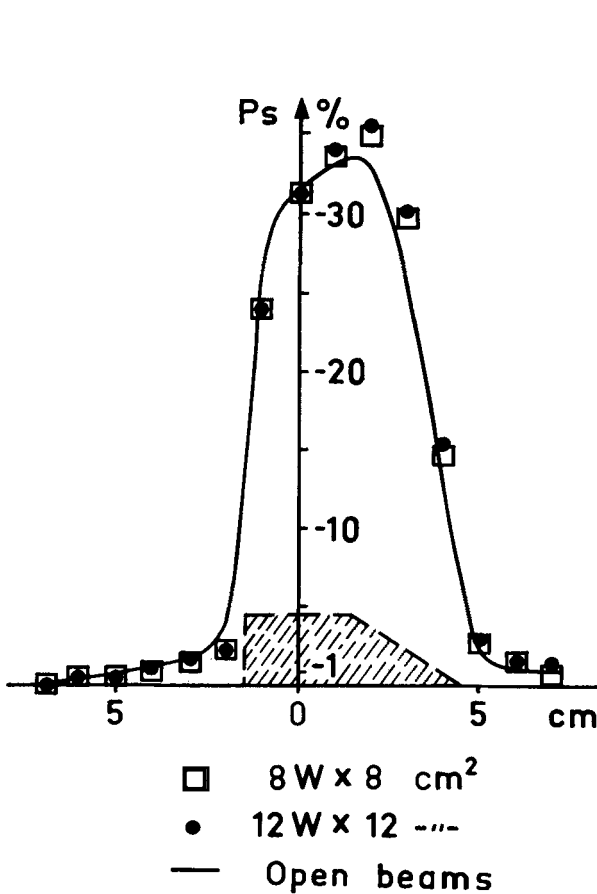


Fig. 2. Differences in dose rate with and without the shielding filter in the beam, at a depth of 10 cm in the phantom, as a function of the distance to the beam axis. The cross section of the filter is projected to this depth.

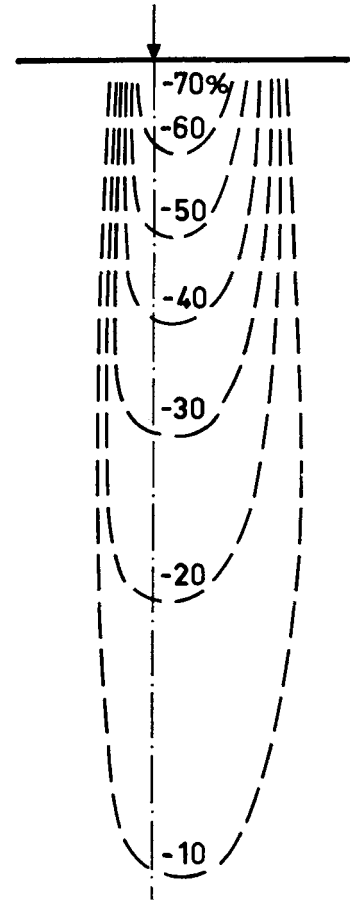


Fig. 3. Subtractive isodose chart for the shielding filter, standardized to the dose in a beam with field size 12 x 12 cm at a depth of 0.5 cm in the phantom.

Measurements and calculations were made in a corresponding way, using a field size of 12 x 12 cm, with the filter displaced 1.5 cm in the principal plane in both directions relative to the position in the above mentioned experimental set-up. Because of the divergence of the gamma rays, this is equivalent to a displacement of ± 2.25 cm at a depth of 10 cm in the phantom. With the filter at the origin of the diagram, the calculated values of the dose-rate reduction are within $\pm 2\%$ of the curve in Fig. 2.

If a shielding filter is to be used in a beam with wedge filter, it may be

necessary to establish a separate subtractive isodose chart, because the radiation is attenuated by the thickness of a filter according to an exponential function, whereas the subtractive isodose chart is established by subtraction. In order to illustrate this, measurements corresponding to the above mentioned experiments were performed, using beams with wedge filter and field sizes of 8×8 cm and 12×12 cm. Thus, the dose rates measured in the beam without shielding filter were subtracted from the corresponding values obtained with filter in the beam. The resulting values were multiplied by the quotient of the dose rates at a given point determined by the position of the shielding filter without and with wedge filter in the beam. This point corresponds to the origin in Fig. 2. The differences in the calculated values at the different points, and with different field sizes and varied positions of the shielding filter, are within $\pm 2\%$.

The calculated values along the line at the depth of 10 cm are shown in the diagram (Fig. 2), from which will be seen that they do not coincide with the curve established for open beams. The difference for the highest value (at the point 2 cm to the right) is 6%.

It may thus be concluded that one isodose chart can be used for open beams independently of field size, but that it may be necessary to establish separate charts for beams with and without wedge filter.

The subtractive isodose chart for the shielding filter when placed in an open beam is given in Fig. 3. This chart was drawn by graphical subtraction of the isodose curves measured for an open beam, field size 12×12 cm, from the curves with filter in the same beam.

SUMMARY

It is sometimes desirable in radiotherapy to protect tissue enclosed within a volume which is to be given a high dose. The protection can be achieved by inserting absorbers (shielding filters) in suitable positions in the beam. The influence of these filters on the dose distribution may be described with 'subtractive isodose charts' which will facilitate dose planning with shielding filters arbitrarily placed in different beams. The accuracy obtained is satisfactory.

ZUSAMMENFASSUNG

In Radiotherapie ist es manchmal wünschenswert, Gewebe innerhalb eines Volumens zu schützen, das einer grossen Strahlendosis ausgesetzt werden soll. Dies kann durch Anbringen von Abschirmungsfilttern im Strahlenbündel erreicht werden. Der Einfluss dieses Filters auf die Strahlendosisverteilung kann mit subtraktiven Isodosendiagrammen illustriert werden, was die Planierung der Strahlendosisverteilung bei der Verwendung von Filtern in verschiedenen Strahlenbündeln erleichtert.

RÉSUMÉ

Pour protéger les tissus en radiothérapie à dose élevée, on peut utiliser des absorbeurs (filtres de protection) placés dans le faisceau dans une position convenable. On peut déterminer leur influence sur la distribution de dose grâce à des 'cartes d'isodoses soustractives'. Ceci permet d'établir simplement le plan d'irradiation pour des filtres de protection placés arbitrairement dans divers faisceaux. La précision obtenue est satisfaisante.

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