CONSIDERATION OF FACTORS FOR THE DETERMINATION OF THE ABSORBED DOSE FROM EXPOSURE MEASUREMENTS IN THE BEAM OF $^{60}$Co TELETERAPY UNITS

By

L. Bozóky
NATIONAL ONCOLOGICAL INSTITUTE, BUDAPEST

J. Nagl and J. G. Haider
INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, AUSTRIA

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Most frequently the absorbed dose is determined by calculations from exposure measurements with ionization chambers. In order to check the calculations, we have examined the ratio rad/Röntgen depending on the depth in the material by direct measurement of the absorbed dose with a graphite calorimeter and exposure with an ionization chamber calibrated for $^{60}$Co radiation. These measurements were performed in the beam of two special $^{60}$Co teletherapy units. The difference of 9 per cent in the ratio mentioned above can be explained by the details of construction and the amount of scattering material in the vicinity of the radiation source, which changes the energy spectrum of the radiation beam to different extents. Therefore, for reasonable accuracy, the factor $f_{exp}$ should be determined by direct measurement for each type of $^{60}$Co teletherapy unit.

Introduction

In all countries using high energy radiation for radiotherapy, radiobiology and similar purposes many scientists have tried to find a solution for the determination of the absorbed dose from exposure measurements during the last twenty years. For various reasons the problems can be solved by calculation only to a certain extent. First of all, because of the different interactions of high energy ionizing radiation with solid, liquid and gaseous matter and the complicated physical processes involved in energy transfer. In addition, for biological reasons even small amounts of absorbed dose of lower energies could produce significant biological effects.

Because of the wide use of high energy radiation, proper dosimetry is most important. The International Commission of Radiation Units and Measurements (ICRU) has treated this field extensively in ICRU Report 10b (1962) and ICRU Report 14 (1969). The method most frequently used for absorbed dose determination is based on exposure measurements in the medium concerned with a calibrated ionization chamber at a position located sufficiently
deep in the material. The calculation of the absorbed dose from the exposure value determined by measurement is discussed in ICRU Report 10b and, in a different manner, in ICRU Report 14. In Report 14 two energy ranges, namely photons generated below 0.6 MeV (case A), and photons generated above 0.6 MeV (case B) are considered in a different manner. For the lower energy range the probe may be treated as a photon detector, whilst for the higher energy range, using a different approach, the probe should be considered as an electron detector. For $^{60}$Co radiation the primary photon energy is 1.17 MeV and 1.33 MeV. However, the immediate vicinity of the $^{60}$Co capsule and the collimator emits scattered and fluorescent X-radiation, which must also be considered if we convert exposure into absorbed dose.

For air:

$$D_{A\text{(rad)}} = 0.869 \cdot X_{(R)}$$

where $D_{A\text{(rad)}}$ is the absorbed dose in air, given in rad, and $X_{(R)}$ is the exposure in R, measured and corrected for SPT and calibration factor $k_I$.

For the medium concerned, the absorbed dose will be calculated as

$$D_M = \frac{(\mu_{en}/\rho)_M}{(\mu_{en}/\rho)_A} \cdot D_A \quad \text{(in case A)}$$

$(\mu_{en}/\rho)_M$ is the mass-energy transfer coefficient for the medium concerned.

In case B, as the sensitive volume is an electron detector, the relation is determined by the ratio of the mass collision stopping powers, $\tilde{s}_{M,A}$ being the average value for the medium and air

$$D_M = \tilde{s}_{M,A} \cdot D_A, \quad \text{(in case B)}$$

where

$$\tilde{s}_{M,A} = \frac{\langle \tilde{s}/\rho \rangle_{\text{coll}, M}}{\langle \tilde{s}/\rho \rangle_{\text{coll}, A}}.$$

Table 2.1 of ICRU Report 14 gives the values for $\tilde{s}_{C,A}$, which are valid for carbon and air:

<table>
<thead>
<tr>
<th>Electron energy in MeV</th>
<th>$\tilde{s}_{C,A}$</th>
<th>$f = 0.869 \cdot \tilde{s}_{C,A}$</th>
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<tbody>
<tr>
<td>0.05</td>
<td>1.017</td>
<td>0.884</td>
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<td>0.1</td>
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