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Radiation Dosimetry of Internally Administered Beta Ray Emitters: Status and Prospects[1]

LEONIDAS D. MARINELLI, M.A.

THE EVALUATION of the absorbed dose in biological media containing radioactive isotopes has been the object of some excellent reviews in the recent radiological literature (1–3). It is the purpose of this paper to summarize concisely the present status of the art and to speculate as to its future prospects, limiting our considerations to beta ray emitters.

We may treat the problem most simply, perhaps, by considering the dose at a given point P in a medium under three general conditions chosen according to their mathematical complexity, namely:

Case I. The point is within a homogeneous medium containing a uniform concentration, C, of radioelement extending from P to distances greater than the range, R, of the most energetic particle emitted by the isotope.

Case II. Within a spherical surface of radius R, the point in question is only partially surrounded by one or more zones of uniform concentration.

Case III. Within the same sphere, the concentration is not uniform, regardless of the spatial extent of the radioactive zone.

Case I: In this case the total dose, D_β, can be computed as (4, 5)

$$D_\beta(\text{rads}) = K_\beta C \qquad (1)$$

where

K_β = $73\,\bar{E}_\beta T_{eff}$ rads
$\bar{E}_\beta$ = the average energy per disintegration in mev
T_{eff} = actual half-life of the isotope in the tissue, or its equivalent, in days
C = concentration in μc/gram

Values for $\bar{E}_\beta$ have been published for the most popular isotopes (6) and are based on the disintegration schemes provided by the contemporary literature in physics. The half-life T_{eff} refers, of course, to the decay rate in the tissue and not to the physical constant. In those cases where the characteristics of isotope turnover cannot be described in terms of a single half-life, it is necessary to express the total number of disintegrations per gram in units of microcurie-days and calculate the dose according to Equation 1, by substituting this value for the product CT_{eff}.

Of practical importance is the accurate determination of the concentration C which, of course, involves the accurate measurement of the disintegration rate of a sample. This particular task has presented some difficulties in the past but has become manageable in the last few years. The interested reader is referred to the comprehensive report of Manov (7) issued recently by the National Research Council. It is pertinent to recall at this point that in homogeneous media, of uniform concentration and known stopping power, the dose D_β can be measured directly by cavity ionization methods, and most simply by the extrapolation chamber, irrespective of the disintegration scheme; both direct and indirect inquiries into the exactness of Equation 1 by various workers have confirmed its essential validity (8–11).

Although the case just considered is of limited value in many biological problems, it has proved useful in guiding both the

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