nm/BOOK REVIEWS

RADIATION QUANTITIES AND UNITS. ICRU Report #19. International Commission on Radiation Units and Measurements. Washington, D.C., 1971, 21 pp, $2.50.

This report is divided into two parts: I, "Fundamental Quantities and Units"; and II, "Quantities and Units for Use in Radiation Protection". In Part I new definitions are provided for the quantities characterizing a radiation field. These quantities (absorbed dose, exposure, kerma, fluence, and energy fluence) are now defined as the derivatives of the mean value of a suitable stochastic quantity (i.e., a quantity which fluctuates in a random manner according to some rule of probability). In my opinion, this results in a useful conceptual clarification, and it renders obsolete discussion of what happens to these quantities when the number of interactions is so small that statistical fluctuations of the absorption process become dominant. These new definitions serve to clarify the status of the quantities in question, without suggesting any change in measurement procedures, in somewhat the same way that the introduction of the quantity *exposure* clarified the status of the unit *roentgen* without suggesting any change in the measurement procedure. These new definitions have been introduced because the "introduction of the concept of stochastic quantities leads to a more rigorous definition of" the quantities which characterize the field. While I share that view, and I welcome this change, it is my opinion that—for reasons which are too technical to give here and which in any event are not of importance in nuclear medicine—the formalism used in Report #19 falls short of the desired rigor.

From the viewpoint of nuclear medicine, the important point is that the familiar quantities have not changed: absorbed dose is still absorbed energy per unit mass (with the special unit, the rad), exposure is still ionization per unit mass of free air (with the special unit, the roentgen), and activity is still nuclear transformations per unit time (with the special unit, the curie). With one exception, the changes in the definitions will have little impact on theory or practice in nuclear medicine.

That one exception has to do with the specific gamma-ray constant, Γ, which has metamorphosed into the *exposure-rate constant,* with the symbol Γ_δ. The exposure-rate constant is defined exactly as was the specific gamma-ray constant, except that (A) it includes only photons of energy greater than δ keV and (B) it includes all photons associated with a given nuclear transformation, both x-rays and gamma rays. The relationship between the earlier quantity, Γ, and the newer quantity, Γ_δ, is shown by setting $\delta = 0$, and noting that

$$\Gamma_0 = \Gamma + \text{any x-ray contribution.}$$

Presumably the rationale behind the low-energy cutoff of this new quantity, Γ_δ, is that the low-energy photons are readily absorbed and do not contribute to the exposure (or the absorbed dose) after the radiations have passed through a certain amount of matter. Probably the exposure-rate constant, Γ_δ, will find its greatest application in radiation protection calculations where a certain degree of protection can be considered to have virtually eliminated the photons with energies below some given energy. It is probable that the exposure-rate constant arrives on the scene too late to play any important role in the internal dosimetry of distributed gamma-ray emitters. The publication of accurate gamma-ray point kernels has made both the old specific gamma-ray constant and the new exposure-rate constant obsolete for dosimetry of biologically distributed radionuclides.

In Part II the *dose equivalent* is defined in the usual terms, i.e., as the product of absorbed dose times quality factor times other modifying factors, the result being in rems if the absorbed dose is in rads. The notation for dose equivalent is updated, the ugly notation DE and QF now being replaced by H and Q for dose equivalent and quality factor, respectively. (While no doubt this arbitrary change in notation will be a minor inconvenience for some, I believe it is useful.) The big news in Part II is, however, that two new quantities are introduced: the *absorbed dose index* (in rads) and the *dose equivalent index* (in rems). These quantities are defined as the maximum values, in a sphere of tissue-equivalent material 30 cm in diameter, of the absorbed dose and the dose equivalent, respectively. These are straightforward proposals, which present no conceptual difficulties, but they are rather special and are intended to be "useful in circumstances where it is difficult to estimate the maximum absorbed dose and dose equivalent in the externally irradiated human body from measurements in air." Useful as these concepts may be in the mixed radiation fields of nuclear power installations, it seems unlikely that they will find application in nuclear medicine in the near future for a number of reasons: (A) as a rule measurements in air are quite satisfactory for estimation of radiation safety in nuclear medicine where the quality factor is unity and protection calculations can be made directly in rads; (B) the difference between the absorbed dose index and the estimated maximum absorbed dose to the human torso is likely to be of no great consequence; and (C) nuclear medicine is frequently concerned with situations where a 30-cm diam phantom is not appropriate, as for example in considering the absorbed dose to the fingers in carrying out a certain procedure. Thus there seems to be no pressing reason for changes in the radiation protection aspects of nuclear medicine, at least based on the contents of *ICRU Report #19*.

It may be worth noting that the ICRU reports are coming out in such rapid succession that there is a problem of self-consistency. Reports 18 and 20 use the specific gamma-ray constant which Report 19 abolishes. Report 19 declares the existence of the absorbed dose index and the dose equivalent index, while Report 20 can do no more than take note of their existence without incorporating them into the body of its findings, even though Report 20 is concerned with the subject for which the two new concepts were devised. This problem of course arises because each ICRU report is many years in preparation, and a number of reports are being worked on simultaneously. Nevertheless, these differences in usage between reports does to a certain extent weaken the effectiveness of the ICRU reports in producing that "uniformity in reporting" which is one of their stated purposes.

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PROGRESS IN ATOMIC MEDICINE, Vol. 3 in Recent Advances in Nuclear Medicine. Edited by John H. Lawrence. Grune & Stratton, New York, 1971, 246 pp, $15.

The scope of scientific knowledge included in the specialty known as nuclear medicine expands at an ever increasing annual rate. For this reason, it is of particular value to have volumes produced such as this one which present the state of the art in important areas within the specialty of nuclear medicine. In addition, it is important to periodically review and discuss fundamental concepts of radiobiology and nuclear medicine.

This volume, the third in an excellent series, maintains the high level of excellence found in the first two volumes. The volume includes an excellent table of contents and a highly usable index. There are 20 contributors to the volume, which contains seven chapters ranging in length from 20 to 75 pages. Each chapter has an extensive comprehensive list of references, including many references to current literature.

Chapters 1, 2, and 3 are relatively short chapters concerned with three areas of current interest in the field of nuclear medicine. Chapter 1 discusses the potential use of radioisotopes for the possible diagnosis of cancerous growths at an early stage, for example, when the neoplasm consists of only 10^6 cells. Chapter 2 reviews the long use of radioiodine in the treatment of thyroid disease and presents the latest information in this important area. Chapter 3 presents current knowledge about the role of the cyclotron in the production of short-lived radioisotopes and positron emitters.

Chapter 4 discusses trace elements, their role in biology and medicine, current methods for determination of trace elements, and specific information concerning the trace elements selenium, chromium, and cadmium. This chapter is 75 pages long, almost one-third of the entire volume, and includes 16 pages of references.

In Chapter 5, the concept of the safe tracer dose is reviewed in detail. This is a topic which should be of interest to all individuals involved in the field of nuclear medicine since patient safety and protection must always be of paramount interest.

Chapters 6 and 7 are concerned with the use of high-LET (linear energy transfer) radiation in radiation therapy, including heavy particles, pi mesons, and fast neutrons. In Chapter 6, the physical and radiobiological characteristics of high-LET radiations are considered in detail. In Chapter 7, the application of these high-LET radiations to the treatment of such diseases as acromegaly, Cushing's disease, Nelson's syndrome, and nonfunctioning pituitary adenomas is discussed including specific case histories.

This volume should make a welcome addition to the professional library of those individuals involved in nuclear medicine, either in treatment of patients or research.

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