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THE IMPACT OF RISK CONSIDERATIONS ON DOSIMETRY OF RADIOPHARMACEUTICALS

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Estimates of the absorbed dose from clinical procedures involving the administration of radiopharmaceuticals are used primarily to determine the presumed risk of various procedures so that, in-so-far as possible, the selection of a given procedure can be based on a comparison of risk. Although this has been the basic objective, risk evaluation has generally been separated from the dosimetry considerations. In the recent revision of its radiation protection guidance,[1,2] the International Commission on Radiological Protection (ICRP) has embodied risk considerations in its recommendations and risk concepts have become an integral part of the dosimetric framework. The impact of these considerations on the dosimetric assessments of radiopharmaceuticals and the resulting need for additional information is discussed.

The introduction of risk considerations has altered the list of target organs from that generally considered in dosimetric assessment of radiopharmaceuticals. The tissues at risk, as considered by the International Commission on Radiological Protection (ICRP), are identified in Table 1 together with their respective risk factors. The sum of the individual organ risks yields a total cancer mortality risk of 1.25×10^{-2} Sv^{-1} which, with the genetic risk factor of 4×10^{-3} Sv^{-1}, results in a total risk of 1.65×10^{-2} Sv^{-1}. The relative contribution of each organ to the total risk is shown in the third column of the table.

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Complete dosimetric data for two organs identified to be at risk, namely, the breast and bone surfaces, are not presently available. In the case of the breast, the need can be met in a rather straightforward manner[3-5] employing conventional dosimetric methodologies. Committee 2 of the ICRP has used the absorbed fraction data for muscle in their estimation of the breast dose.

The consideration of the skeletal tissues at risk is complicated by the nature of the skeleton. For dosimetric purposes, two bone types are identified: trabecular bone, which contains the active red marrow, and cortical bone, which lies to the exterior. The ICRP considers the 10 μm layer of tissue adjacent to the surface of trabecular and cortical bone as the relevant target as well as the red marrow. To evaluate the dose to these tissues, the activity residing in cortical and trabecular bone must be assigned and specific absorbed fractions for these tissues available. As the range of nonpenetrating radiations is comparable to the dimension of the source and target regions, consideration must be given to whether the activity is on the surface or in the volume of the bone.

The pioneering efforts of F. W. Spiers and coworkers[6,7] have resulted in a considerable amount of information on the dosimetry of bone seekers, particularly beta emitters. The ICRP, utilizing this information, has recommended nominal values for the absorbed fractions. Many of the radionuclides of interest in nuclear medicine emit a considerable fraction of their energy via conversion and Auger electrons. Further consideration of the absorbed fractions for these as well as positron radiation is necessary.

The dose to the target regions is dependent on knowledge of the time integral of the activity residing not only in identified source

regions but also in "other" tissue groups. While consideration of the latter may have been of minor importance in the past, the introduction of the risk considerations alters this generalization. Thus, it remains crucial to continue efforts to obtain further understanding of the metabolic behavior of the administered radiopharmaceutical, particularly with respect to uptake in the two bone types.

The major impact of risk considerations has been a focusing of the dosimetry methodologies on the relevant target regions of the body. Past attention was too often limited to the target region receiving the highest dose. Evaluation of alternative procedures frequently results in changes in the identity of the critical organ as well as changes in the dose to less irradiated tissues. In this respect, the quantity H_E defined by the ICRP as $\sum w_T H_T$, where H_T is the dose to tissue T and w_T the weighting factor of Table 1, appears to be a dosimetric quantity of considerable utility. Until improved dosimetric data become available, those performing risk assessments of administered radiopharmaceuticals should consult the recent ICRP Publication 30 for current state-of-the-art computational procedures.

Table I. Stochastic risk and organ weighting factors[a]

Organ/Tissue	Risk (Sv^{-1})	W_T
Gonads	4.0×10^{-2}	0.25
Breast	2.5×10^{-2}	0.15
Red marrow	2.0×10^{-2}	0.12
Lung	2.0×10^{-2}	0.12
Thyroid	5.0×10^{-3}	0.03
Bone surfaces	5.0×10^{-3}	0.03
Remainder[b]	5.0×10^{-2}	0.30
Total	1.65×10^{-1}	

[a] Values set forth in ICRP Publication 26.

[b] "Remainder" represents the risk of cancer in nonspecified tissues of the body. In application of the W_T for this class of tissue, the weight is applied equally to the five remaining organs or tissues receiving the greatest dose. Skin and lens of the eye are not considered in this tissue group.

REFERENCES

1. International Commission on Radiological Protection, *Annals of the ICRP*, Vol. 1, No. 3, Pergamon Press, 1979.

2. International Commission on Radiological Protection, *Annals of the ICRP*, Vol. 2, No. 3/4, Pergamon Press, 1979.

3. R. Loevinger and M. Berman, MIRD Pamphlet No. 1, Revised, New York, Society of Nuclear Medicine, 1976.

4. M. Cristy, ORNL/NUREG/TM-367, 1980.

5. W. S. Snyder, M. R. Ford, and G. G. Warner, MIRD Pamphlet No. 5, Revised, New York, Society of Nuclear Medicine, 1978.

6. J. R. Whitwell and I. W. Spiers, [illegible] 21, 16, 1976.

7. I. W. Spiers, J. R. Whitwell, and A. H. Beddoe, [illegible] 23, 48, 1978.