BOOK REVIEW

NATIONAL COUNCIL ON RADIATION PROTECTION
AND MEASUREMENTS NCRP REPORT No. 89
Genetic Effects from Internally Deposited Radionuclides
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Exposure to radiation can result in genetic effects as a result of damage to germinal tissue. In the absence of quantitative human information, the assessment of risks in man must be based upon studies with experimental animals or other cellular systems. Most information from animal studies comes, however, from work with external radiation and there are only limited data on the consequences of intakes of radionuclides. It is important, nevertheless, to assess the genetic consequences of internally incorporated radionuclides and to determine whether their effect on germinal tissues could be different to that of external radiation.

The stated purpose of this report by a Committee of the National Council on Radiation Protection and Measurements USA is to "update the information available from animal and cellular experiments that relate genetic effects to deposited radioactivity and dose from internally deposited radioactive materials". For various types of radiation genetic damage from internal emitters is compared with that resulting from exposure to external acute or protracted radiation to provide a basis for estimating the relative genetic hazard.

Information on genetic damage in animals resulting from intakes of radionuclides is available for a number of standard indices. These include the induction of dominant lethal mutations, assays of cytogenetic damage in reproductive tissue and the induction of specific locus and dominant skeletal mutations. As the number of studies with standard genetic endpoints is limited however, the authors of the report have also drawn on a number of other studies considered to be relevant to the assessment of genetic damage in man. These are the induction of chromosome aberrations in human lymphocytes in culture, the induction of cytogenetic damage in somatic tissue and studies on the effects of alpha irradiation on cells in culture.

Most of the information on the effects of beta emitters relates to tritium and carbon-14. The data available suggest that for carbon-14 genetic

effects should be calculated on the basis of absorbed dose with an effectiveness relative to protracted low LET radiation of 1. There is no evidence of a significant transmutational effect resulting from the incorporation of carbon-14 in macromolecules in cells. For tritium, experimental results also suggest that transmutation is a minor consideration but that it should be considered to be twice as effective as gamma rays for the production of genetic damage on the basis of absorbed dose.

Surprisingly, there is very little information on the effects of high energy beta-gamma emitting radionuclides with only two references cited from the 1980s. The results suggest that for comparable doses and dose rates beta-gamma radiation from internally incorporated radionuclides is equivalent to that from external low LET radiation.

Much more interest has focused on the consequences of intakes of alpa emitters, particularly plutonium-239, and this is the main emphasis of the report. The problems of applying the results of animal experiments to man are well demonstrated in the case of work with this radionuclide. Auto-radiographic studies have demonstrated that plutonium-239 in the mouse testis is largely accumulated by phagocytic cells in interstitial tissue, but that the sensitive spermatogonial stem cells are within alpha particle range. The calculated dose to these cells in the mouse is, as a consequence, about two to four times greater than the average dose to the organ. Because in primates there is a greater ratio of interstitial tissue to reproductive tissue and a greater separation between them no dose enhancement to the spermatogonial cells due to non-uniform distribution is likely to occur in man. Thus, studies in rodents comparing the effects of plutonium with external radiation will tend to give values for relative biological effectiveness (RBE) that are conservative for application to man.

In the light of the evidence available and because of the range in RBE values obtained for different measures of genetic damage resulting from alpha particle radiation, it was concluded that a quality factor of 20 was a sufficiently cautious value to apply to genetic damage resulting from alpha radiation relative to protracted low LET radiation. It was noteworthy that the Committee considered that as most available information on the genetic effects of alpha emitters related to plutonium, which distributes very heterogeneously in the testes, more data on the effects of alpha emitters that distribute uniformly throughout the tissue is needed.

A main conclusion of the report is that, after allowing for the greater effectiveness of alpha irradiation in inducing damage, all the data available suggest there is little evidence for a unique genetic hazard

resulting from internally deposited radionuclides which could not have been predicted from external exposure data. Specific-locus mutations induced by alpha irradiation do, however, appear to be qualitatively more severe than those induced by gamma rays, suggesting that a high proportion of them are multi-locus deficiences.

In summary, the report provides a worthwhile and very readable review of information available on the consequences of irradiation of germinal tissue from internally incorporated radionuclides. It will be a valuable reference source for anyone concerned with this aspect of radiation biology. Other NCRP Publications are listed also in this Report.

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