Dosimetry of heterogeneously distributed radionuclides with applications to radioimmunotherapy

Douglas John Simpkin

The dosimetry of internally deposited radionuclides has been investigated for applications to radioimmunotherapy. The assumptions inherent in the MIRD method of dose calculation are shown to be inappropriate to the task of dosimetry for nonuniformly distributed radionuclides emitting lowly penetrating radiations. A method using the concept of dose point kernels has been developed, expanding the MIRD method to regions of charged particle disequilibrium and heterogeneous media.

Using the EGS4 Monte Carlo code, dose point kernels in H$\sb2$O were calculated for electron and photon emissions. Discrepancies were found with kernels in the literature, due either to errors in the techniques of the published kernels or inappropriate assumptions made in their calculation.

In a homogeneous medium, the dose point kernels were convolved with known radionuclide concentrations using fast Fourier transform techniques. For spherically symmetric distributions, this is achieved very rapidly using the discrete one-dimensional fast Fourier transform. For concentrations which are independent of one dimension, the convolution reduces to a problem utilizing two-dimensional Fourier transforms.

In heterogenous media, the dose point kernels may be convolved with radionuclide concentrations given the assumptions of density scaling and dose reciprocity. This may be achieved rapidly using a numerical N-body solution. The effects of distant sources are thus considered collectively rather than discretely. Two N-body schemes are presented. The "virtual source" N-body code is applicable for source distributions that are very discontinuous, while the "integral absorbed fraction" code accurately determines the dose rate due to uniformly distributed radioactivity. These schemes are confirmed by Monte Carlo calculations for mixed phantoms of H$\sb2$O, bone, and steel.

As an aid to determining the location of beta emitting nuclides in vivo, the spatial and energy distributions of bremsstrahlung emission and positron annihilation about point sources was determined in H$\sb2$O using the EGS4 Monte Carlo code.