ABSTRACT

In radionuclide therapy it is important to obtain a high absorbed dose to the tumour while the absorbed dose to the normal tissue is kept below critical limits. The organ that limits the dose depends on the radiopharmaceutical used. Charged particles, such as electrons and alpha particles will, in principle, give an absorbed dose locally to regions that have an activity uptake. However, photons will cause non-specific irradiation of the whole body. This can lead to a high absorbed dose, for example, to the radiosensitive bone marrow. Therefore, it is important to take the photons emitted into consideration when investigating radionuclides for potential use in radionuclide therapy.

Electron- and alpha-emitting radionuclides in use or proposed for use in radionuclide therapy, together with a selection of electron-emitting radiolanthanides, in total 82 radionuclides, were dosimetrically investigated for use in radionuclide therapy. The ratio of the mean absorbed dose rate to the tumour and normal tissue ($TN\dot{D}$) was calculated for different subcellular activity distributions and tumour sizes, as well as for different body sizes, representing mice, rats and humans, in order to investigate how the absorbed dose arising from the emitted photons depends on the body size. The electron- and alpha-emitting radionuclides could be divided into 9 groups according to their $TN\dot{D}$ values. Radionuclides emitting particles with short ranges showed high $TN\dot{D}$ values for all tumour sizes, while those with high photon emission showed low $TN\dot{D}$ values. Six of the radiolanthanides studied may be interesting for radionuclide therapy according to their $TN\dot{D}$ values and production possibilities: ^{149}Pm, ^{161}Tb, ^{161}Ho, ^{166}Ho, ^{167}Tm and ^{177}Lu. High photon emission also reduced the $TN\dot{D}$ values as the body sized increased. It is, therefore, important to be careful when translating preclinical results obtained in mice or rats to clinical situations in humans.

The tumour control probability (TCP) may be a better quantity for investigating the therapeutic outcome than the absorbed dose. TCP takes the radiation sensitivity and the absorbed dose to the cells into consideration, as well as the number of cells in the tumour. TCP was calculated for four radionuclides with different particle ranges: ^{90}Y, ^{177}Lu, ^{211}At and ^{103m}Rh. Different macroscopic, as well as subcellular, activity distributions were studied for different tumour sizes. TCP was highly dependent on the different activity distribution when the self-absorbed dose dominated, e.g. when radionuclides emitting short-ranged particles were located close to the nucleus. When the cross-absorbed dose dominated, the macroscopic activity distribution was not of great importance. This was the case for the radionuclides emitting long-ranged particles and when the radionuclides emitting short-ranged particles were distributed over the cell membrane.

There are several methods of performing electron dosimetry. One is to use scaled point kernels. Point kernels can be used together with geometric factors to calculate absorbed fractions in different geometries. Point kernels were generated with the mixed Monte Carlo code PENELOPE-2006 and were compared with previously published point kernels generated with different condensed-history Monte Carlo codes. The results of the different codes differed up to 14% for distances less than 0.9 r/R_{CSDA} from the source. However, when the point kernels were used to calculate S-values the differences decreased to below 10%.

Keywords: Dosimetry, Radionuclide therapy, TCP, Electrons, Alpha particles, Photons, Monte Carlo, Point kernel

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