Microdosimetry of radiohalogens in thyroid models

AKADEMISK AVHANDLING

som för avläggande av medicine doktorsexamen vid Sahlgrenska akademin vid Göteborgs universitet kommer att offentligen försvaras i hörsal Arvid Carlsson, Medicinaregatan 3, Göteborg, fredagen den 28 februari 2014, kl 09:00.

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Avhandlingen är baserad på följande delarbeten:

I. Anders Josefsson and Eva Forssell-Aronsson
Microdosimetric analysis of the radiohalogens ^{123}I, ^{124}I, ^{125}I, ^{131}I *and* ^{211}At
Submitted

II. Anders Josefsson and Eva Forssell-Aronsson
Microdosimetric analysis of ^{211}At *in thyroid models for man, rat and mouse*
EJNMMI Res. 2012, 2:29

III. Anders Josefsson and Eva Forssell-Aronsson
Microdosimetric modelling of ^{123}I, ^{125}I *and* ^{131}I *in thyroid follicle models*
Submitted

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Microdosimetry of radiohalogens in thyroid models

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Abstract

The radiohalogens ^{123}I, ^{124}I, ^{125}I, ^{131}I, and ^{211}At are routinely used or proposed for diagnostic and therapeutic purposes. The different characteristics and application areas of these radioiodine isotopes, together with the possibility to bind them to the same carrier molecule, give many advantages, for example, by enabling relevant biodistribution and dosimetric studies important for dose-planning before radionuclide therapy. ^{211}At, with its relatively long half-life, stable daughter nuclide, and production and labelling possibilities is considered as one of the most attractive alpha particle emitters in radionuclide therapy. With growing use of radiohalogens in both preclinical and clinical studies there is a need for accurate species-specific dosimetric models both for tumours and normal tissues. The thyroid gland has shown a high uptake of radioiodide and free ^{211}At and is, therefore, considered as an organ at risk. It is thus critical to be able to accurately calculate the absorbed dose in the thyroid. Accurate dosimetry is also important for radiation protection purposes for personnel handling radiohalogens and for populations exposed to radioiodine, e.g., at a nuclear accident.

The MIRD formalism is commonly used for calculating the mean absorbed dose, assuming a homogeneous distribution of the radionuclide within the thyroid gland. Several studies have shown heterogeneous distribution of radioiodine and ^{211}At within the thyroid gland.

In this work, geometrical models were developed for different species: man, rat and mouse. Microdosimetric calculations for heterogeneous distributions of the different radiohalogens in these thyroid models were performed using MCNPX Monte Carlo code and recent nuclear decay data. The results showed large differences in mean absorbed dose compared with MIRD formalism.

The heterogeneity in absorbed dose within the thyroid depends on the type and energy of the emitted particles. For example, ^{131}I emits high-energy beta particles with range up to 2 mm in tissue, where the absorbed dose distribution within the thyroid is less dependent on the radionuclide distribution. On the other hand, for ^{211}At emitting alpha particles with short range in tissue (48-70 μm), and for ^{125}I emitting Auger electrons with very short range in tissue (from a fraction of a nm up to 20 μm), the absorbed dose distribution will be more dependent on the radiohalogen distribution.

The results also demonstrate the importance of using species-specific models for dosimetric calculations for thyroid and other heterogeneous tissues, enabling dosimetric translations between different species.

Keywords: microdosimetry, Monte Carlo, radiohalogens, radioiodine, astatine-211, thyroid gland, man, rat, mouse

ISBN: 978-91-628-8915-9
E-publication: http://hdl.handle.net/2077/34811